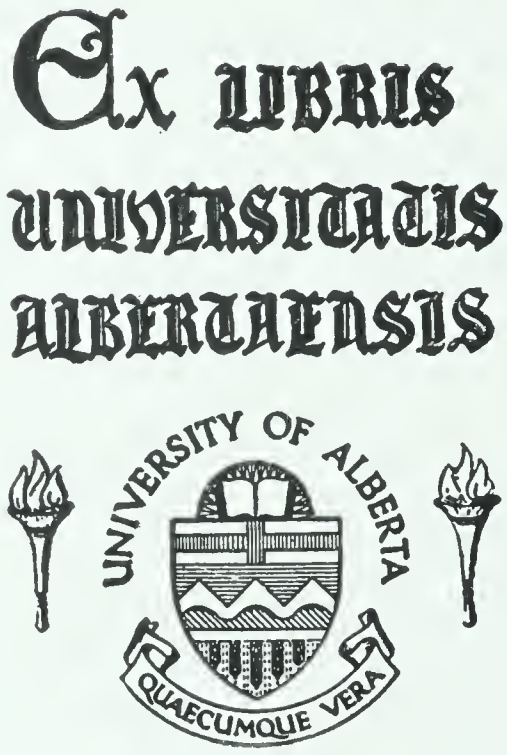

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THE UNIVERSITY OF ALBERTA

PALYNOLOGY OF TYPE McMURRAY FORMATION

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF GEOLOGY

by

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EDMONTON, ALBERTA

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UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Palynology of type McMurray Formation" submitted by A. Vagvolgyi, B.Sc., in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

One-hundred and two species belonging to 45 genera of spores and pollen grains, 8 species representing 5 genera of marine microplankton and 1 species of megaspore of uncertain affiliation are figured and described from the McMurray Formation and basal Clearwater Formation in northeastern Alberta. Four species of spores are proposed as new. The Socony-Vacuum Exploration Company Hole No. 27 (Sec. 27, Tp. 91, R. 10 W of 4th Mer.) provided the microflora.

The microfloral assemblage contains ferns, pteridosperms, cycads and conifers. One specimen of undoubted angiosperm was found in the section, which is the first of its kind in western Canada. The microflora indicates warm, humid climate.

The sudden and abundant appearance of the marine microplankton at the base of McMurray Member 3 indicates an open connection with the advancing Clearwater Sea.

Based on the distribution of the sporomorphae, the section was divided into two zones, one of which was further subdivided into two subzones.

The results of the present study are compared with the findings of the palynological investigation carried out by Singh in Central Alberta.

ACKNOWLEDGMENTS

The writer wishes to thank Professor C.R. Stelck for his guidance and encouragement. Special thanks are due to Mr L. Hills who greatly assisted the writer in the processing and identification of the microflora. The writer is indebted to Dr J.H. Wall of the Research Council of Alberta, who obtained the subsurface samples of the Socony-Vacuum Exploration Company Hole No. 27. The writer acknowledges the help of Dr C. Singh, whose criticism has been most valuable.

The writer wishes to acknowledge financial help in the form of the National Research Council Assistantship, which he held during the academic year 1963-1964.

Miss Sheila Baker typed the manuscript and Mr Frank Dimitrov reproduced the plates.

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CHAPTER ONE - INTRODUCTION

Scope of the project

In this thesis a study of fossil spores and pollen grains of an almost complete core of the McMurray Formation and the basal part of the Clearwater Formation has been undertaken. The main objectives of this palynological study were to determine the microfloral assemblage of the McMurray Formation and basal Clearwater Formation and to establish a succession of their microfloras. An attempt was also made to assign a precise age to these formations, in the Fort McMurray area and to correlate with the lower Mannville beds of the Edmonton area.

Review of previous work

The world's greatest known oil reserve is located in the McMurray Formation [625.9 billion bbls. according to the latest estimates (1963)] and because of its great economic significance a good deal of published information exists on it. Meek (1868) and Macoun (1877) provided the first descriptions of the McMurray area. Bell (1884) published the first scientific report on it and Mcconnel (1893) prepared and published a comprehensive report on the geology of the area.

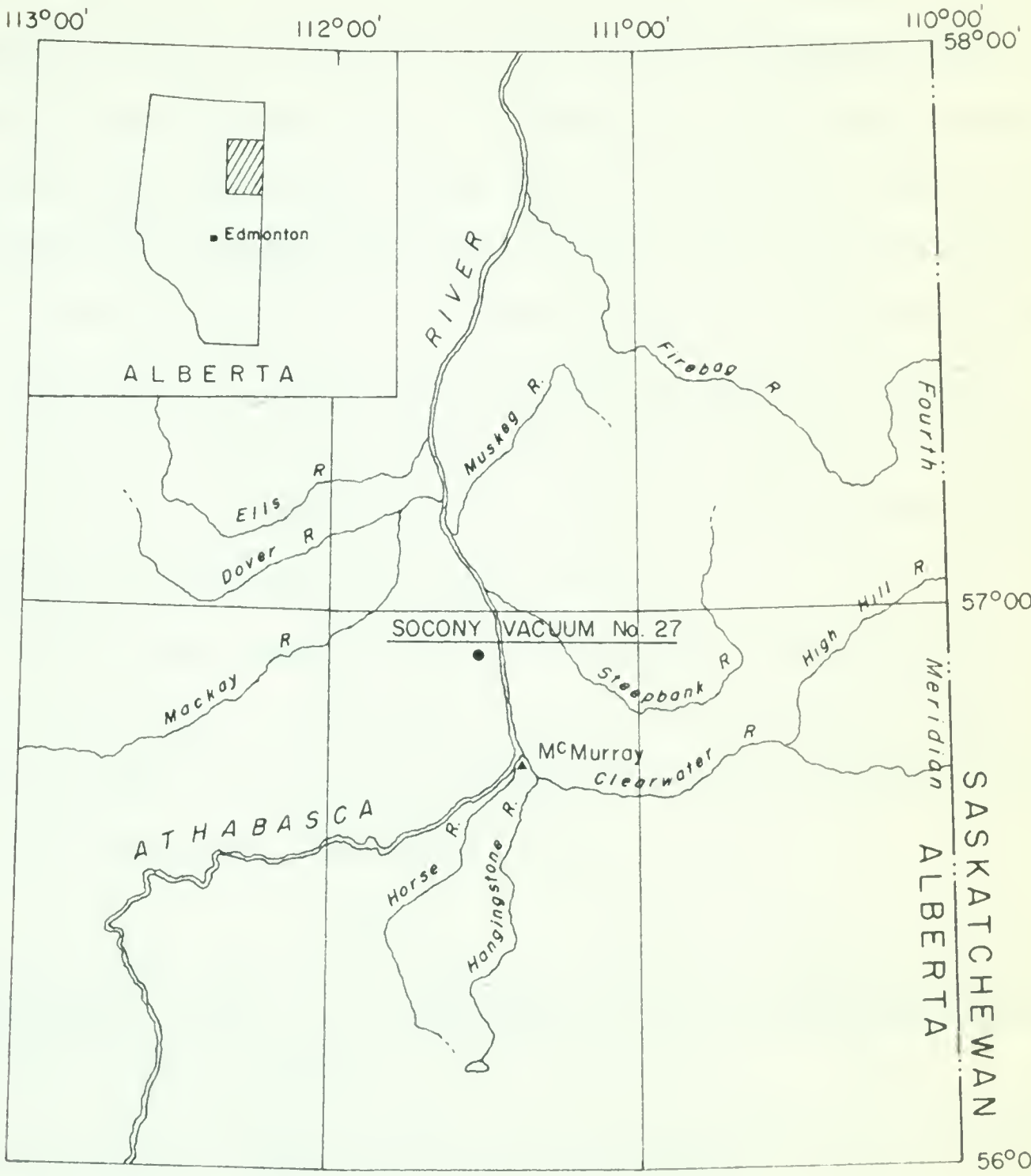
No attempt will be made here to give a complete account of the existing literature. (The reader is referred to the Proceedings of the Athabasca Oil Sands Conference published by the Government of Alberta in 1951 and to the papers of the Second Conference of the Athabasca Oil Sands published by the Research Council of Alberta in 1963). However, a number of studies were recently undertaken which have a direct bearing on this thesis and should be mentioned. In 1956 G.B. Mellon and J.H. Wall of the Research Council of Alberta carried out a detailed investigation of the foraminifera of the Upper McMurray and basal Clearwater Formations and in the

same year Mellon studied the heavy minerals of the McMurray Formation in order to establish the age and source area of these sediments. In 1959 M.A. Carrigy of the Research Council of Alberta carried out further detailed studies of the general geology of the McMurray area. No previous work has been done on the palynology of the type McMurray Formation, but Singh (1963) extensively dealt with the palynology of the homotaxial equivalents of the McMurray Formation and basal Clearwater Formation in the Edmonton area. Pocock (1962) carried out a palynological investigation in southern Alberta in a slightly more cursory manner.

Location of samples

The samples macerated for this study were selected from the core of the Socony-Vacuum Exploration Company Hole No. 27 (Sec. 27, Tp. 91, R. 10 W of 4th Mer.), which is a supplementary subsurface type section of the McMurray Formation (Carrigy, 1959). A total of 134 feet of core (60%) was available for sampling. Recovery loss accounts for 20 per cent and the Socony-Vacuum Company took 54 feet of the samples which accounts for the other 20 per cent. However, the core loss and company samples were evenly distributed throughout the whole core and therefore it was essentially complete for the purpose of this study. The depths of the 25 samples which were processed and examined for microflora, are given in Table 4.

GEOGRAPHIC LOCATION
OF
SOCONY VACUUM EXPLORATION CO. HOLE No. 27



0 20 40

SCALE IN MILES

CHAPTER TWO - STRATIGRAPHY

McMurray Formation

The strata containing the Athabasca oil sands are known as the McMurray Formation. It is located adjacent to the Precambrian Shield in the northeastern corner of Alberta and lies unconformably on Devonian strata. The name McMurray was proposed by McLearn (1917) for the basal Cretaceous oil impregnated quartz sandstones along the lower Athabasca River. The Athabasca oil sands occupy an area of approximately 13,000 square miles. Carrigy (1959) designated a type outcrop section for the McMurray Formation on the east side of Athabasca River three miles north of Fort McMurray in Sec. 5, Tp. 90, R. 9. A supplementary subsurface type section has also been designated based on a set of cores presented to the Research Council of Alberta by Mobil Oil of Canada Limited from Socony-Vaccum Exploration Company Hole No. 27 which was drilled in Sec. 27, Tp. 91, R. 10 in 1953. Samples studied in this thesis were obtained from cores of this latter well.

The stratigraphic sequence of the formations which are most intimately associated with the McMurray Formation in the Athabasca area is shown in Table 1, with thicknesses taken along the lower Athabasca River from Grand Rapids to Bitumount (McLearn, 1917; Wickenden, 1949; Mellon, 1956).

Table 1

Formations	Lithology	Thickness in feet
Grand Rapids Formation	Sandstone, siltstone, some minor shale	360
Clearwater Formation Wabiskaw Mbr	Soft, grey or black marine shale with minor glauconitic sandstone beds; glauconitic beds at base	275
McMurray Formation	Massive to thick, cross-bedded bitumen impregnated sands, shaly and thinner-bedded at the top	200
	unconformity	
Waterways Formation (Devonian)	Fossiliferous limestone and shaly limestone	

The McMurray Formation is conformably overlain by the Wabiskaw Member (Badgley, 1952) a glauconitic sandstone member of the Clearwater Formation and is unconformably underlain by the Upper Devonian Waterways Formation. The McMurray deposits, conglomerates, quartz sands, silts and shales have a thickness of 0 to 350 feet. A detrital zone of white, limy and silty residual clay marks the base of the McMurray Formation and is called the Deville Member (Badgley, 1952). Carrigy (1959) subdivided the McMurray Formation on lithological evidence into three stratigraphic units, namely the Lower, Middle and Upper McMurray Members. The Lower McMurray Member of Carrigy seems to be equivalent to the Deville Member which was described by Badgley (1952). Carrigy in his description notes the presence of ironstone conglomerate lenses, which fill up the lower depressions on the pre-Cretaceous surface. However, neither the surface nor the subsurface type sections designated by Carrigy show the Lower McMurray Member, because at the time when those type sections were designated, no core sections were available which penetrated the lower member. In the surface type section the basal part of the McMurray Formation consists of one foot of ironstone conglomerate. In the supplementary subsurface type section the basal part of the McMurray Formation is represented by ten feet of residual clay. The supplementary subsurface type section modified after Carrigy is given in Table 2.

The Middle McMurray Member of Carrigy (1939) consists of oil-cemented quartz sands of uniform mineralogy. Lenticular beds of micaceous silts, shales and clay are interbedded with the sands.

The Upper McMurray Member of Carrigy (1959) is discriminated from the Middle Member by the presence of a brackish water microfauna (Mellon and Wall, 1956).

Mineralogy and source area of the McMurray Formation

Mellon (1956) studied the heavy minerals from the sandstones of the McMurray Formation which are 90 to 95 per cent quartz grains and classified therefore as quartzose

Table 2

Supplementary Type Section (subsurface)

Socony-Vacuum Exploration Company Hole No. 27

Location: 2,785 feet South of north boundary]
2,504 feet West of east boundary] of Sec. 27, Tp. 91, R. 10

Elevation: 1,061 Total Depth: 296 feet Cored: 223 feet
Recovered: 183 feet

Date Spudded: Sept. 20, 1953 Completed: Sept. 24, 1953

Core is available for inspection at the Research Council of Alberta, Edmonton.

[modified after Carrigy, 1959]

Elevation above mean sea level	Formation	Description of Lithology	Depth in feet	Thickness in feet
1061 feet		Glacial clays and sands, few boulders	0- 73	73
	Clearwater	Dark-grey clay, streaks of silt	73- 93	20
		Fine-grained sands with glauconite	93- 98	5
		Sandstone, with siderite cement	98- 99	1
960 feet	(Wabiskaw member) lower 8 feet	Fine-grained, green sandstone, partly cemented, with a few dark-grey clay beds, odor of oil	99-101	2
	Upper McMurray Member 3	Grey clay with streaks of sand and silt	101-108	7
		Low-grade oil sand with interbedded clay	108-117	9
939 feet		Grey clay with few streaks of silty brown oil sand	117-122	5
	Middle McMurray Member 2	Fine-grained, brown, low-grade oil sand	122-132	10
		Low-grade oil sand, with clay streaks up to 2 inches thick	132-152	20
		Hard siderite-cemented sandstone with trace of oil	152-153	1
		Fine-grained silty oil sand with clay interbeds	153-172	10
		Hard siderite-cemented sandstone with oil	172-173	1
775 feet	McMurray, total 185 feet	Clay and silty clay with oil sand beds up to 1 foot thick, and many sandstone seams with siderite cement about 1 inch in thickness	173-286	113
765 feet	Residual clay over Waterways formation	White limy clay, part silty	286-296	10

sandstones. The purpose of Mellon's study was to establish the source area for those sediments. Mellon reported two distinct suites of minerals and established that the first cycle minerals were derived from an igneous metamorphic terrane of low elevation, and second cycle tourmaline and zircon were derived from pre-existing sediments. Amphiboles and pyroxenes, the so-called unstable minerals, were almost completely absent. Mellon concluded that the McMurray sediments were derived from the east, from a low lying igneous-metamorphic region in the Precambrian Shield and partly from areas where late Precambrian and or early Paleozoic sediments were deposited previously.

Pre-Cretaceous topography in the Athabasca River area, Northeastern Alberta

The McMurray Formation was deposited on an irregular pre-Cretaceous topography developed on the eroded Devonian surface. An ancient topography was created by a major erosional break in the depositional sequence between Devonian and early Cretaceous times. Subaerial erosion and weathering is indicated by white limy and silty residual clays at the base of the McMurray Formation, which although representing a time gap of around 170 million years, may actually represent a post mid-Jurassic break. Collapse of the underlying carbonates caused further depressions on the pre-Cretaceous topography, especially around Fort McMurray and Bitumount. The McMurray deposits filled up the valleys of the pre-Cretaceous surface and thus their thickness was controlled in part by the ancient topography.

The thickness and dip of the lower Cretaceous strata increases westward from the Athabasca oil sands area towards the Rocky Mountains. The dip of these strata is generally five to seven feet per mile to the southwest, but it increases to about 25 feet per mile at the foothills belt. Prior to the deposition of the Cretaceous sediments the Paleozoic strata were tilted of the order of 15 feet per mile to the southwest.

Depositional environment and paleogeography

During middle Early Cretaceous times the Arctic Ocean from the north invaded the interior of British Columbia and part of Alberta and advanced as far south as latitudes of south-central Alberta. The invasion of Arctic sea (Boreal transgression) took place approximately during the Middle Albian Substage. The advancement of the sea was gradual. In the Fort McMurray area distinct environments of deposition can be recognized in the McMurray and in the Clearwater Formations.

The basal part of the McMurray Formation was formed by the accumulation of erosional detritus. The Fort McMurray area was subaerially exposed.

The Middle McMurray Member was laid down as a widely spread fluvial deposit. Later the transgressive sea initiated a shift of environment and the fluvial sediments gave place to lacustrine or lagoonal type of deposits, which are especially common in the Upper McMurray Member.

In the transgressive sea at some distance from the shoreline sand accumulated in the form of ridges, developing offshore bars which became the glauconitic Wabiskaw Member.

The Clearwater Formation marks the maximum transgression of the breal sea. The lagoonal environment changed into shallow neritic environment. The arenaceous microfaunal assemblage of the Upper McMurray Formation was replaced by calcareous microfauna in the Clearwater Formation.

Following the maximum transgression, a regressive phase of the boreal flooding took place. During the regressive phase the Grand Rapid Formation was deposited in a deltaic environment.

Megafossils

McMurray Formation

Gordon (1932) reported tree trunks and wood from the McMurray Formation. Mellon (1959) collected laminae of Ginkgo and a few other plant fragments from

the lower part of the formation.

Russell (1937) described the following faunal species from near the top of the McMurray Formation:

Unio (Elliptio) biornatus Russell

Murraia naiadiformis Russell

Viviparus murraiensis Russell

Lioplacodes bituminis Russell

Goniobasis ?multicarinata Russell

Melania multorbis Russell

Melampus athabascensis Russell

McLearn (1931) reported brackish water pelecypod Astarte natosini McLearn from near the top of the McMurray Formation.

Clearwater Formation

The marine megafauna of the Clearwater Formation has been described by Whiteaves (1892) and McLearn (1919, 1931, 1933) and includes the following species:

Beudanticeras affine (Whiteaves)

Beudanticeras glabrum (Whiteaves)

Subarcthoplites mcconnelli (Whiteaves)

Subarcthoplites cf. belli (McLearn)

?Gastroplites cf. canadensis (Whiteaves)

Entolium irenense McLearn

Camptonectes matonabbei McLearn

Brachidontes athabaskensis McLearn

Nucula athabaskensis McLearn

Inoceramus dowlingi McLearn

Arctica limpidiana McLearn

Yoldia kissoumi McLearn

Goniomya matonabbei McLearn

Psilomya peterpondi McLearn

Psilomya elongatissima McLearn

Protocardia alcesiana McLearn

Onestia onestae (McLearn)

Tellina dowlingi McLearn

Turnus lacombi McLearn

Microfossils

McMurray Formation

Mellon and Wall (1956) report the following microfauna from the Socony-Vacuum Exploration Company Hole No. 27 (Sec. 27, Tp. 91, R. 10):

- Lower part of the McMurray Formation between the depths of 117 and 293 feet

Cypridea

- Upper part of the McMurray Formation between the depths of 101 and 117 feet

Ammodiscus sp.

Haplophragmoides cf. sluzari Mellon and Wall

Haplophragmoides sp.

Miliammina sproulei Nauss var. gigantea Mellon and Wall

Trochammina mcmurrayensis Mellon and Wall

Trochammina? sp.

Verneuilinoides? sp.

Basal Clearwater Formation

The basal glauconitic sand did not yield any microfauna in the Socony-Vacuum Exploration Company Hole No. 27 (Sec. 27, Tp. 91, R. 10). From the basal 19 feet of the Clearwater shale overlying the glauconitic sand Mellon and Wall (1956) reported the following microfauna:

Ostracode

Cytheridea (sensu lato) sp.

Foraminifera

Ammobaculites humei Nauss

Ammodiscus sp.

Bathysiphon sp.

Discorbis norrisi Mellon and Wall

Globulina lacrima Reuss var. canadensis Mellon and Wall

Haplophragmoides gigas Cushman var. minor Nauss

Haplophragmoides sluzari Mellon and Wall

Lenticulina bayrocki Mellon and Wall

Leptodermella? sp.

Marginulinopsis collinsi Mellon and Wall

Marginulinopsis collinsi var.

Miliammina subelliptica Mellon and Wall

Nodosaria aff. proboscidea Reuss

Pseudonodosaria clearwaterensis Mellon and Wall

Quadrimorphina albertensis Mellon and Wall

Saracenaria trollopei Mellon and Wall

Saracenaria trollopei var.

Saracenaria sp.

Tritaxia athabascensis Mellon and Wall

Verneuilinoides? sp.

Age and correlation of the McMurray and basal Clearwater Formations

Microfaunal studies suggest that the foraminifera of the upper McMurray Formation are of early Middle Albian age. The foraminifera of the basal Clearwater Formation are similar to the foraminifera of the Gault Formation of Europe, which is Albian in age.

Mellon and Wall (1956) indicate a zonation of the Middle Albian Substage in the McMurray area (see fig. 3).

The Trochammina mcmurrayensis zone includes the uppermost part of the McMurray Formation and the basal glauconitic sands of the Clearwater Formation in the Socony-Vacuum Exploration Company Hole No. 27. Mellon and Wall (1956) assign a Middle Albian age to the faunas of this zone and correlate it with the Gault of England. The faunal assemblage of this zone indicates brackish water environment in the margins of the McMurray delta.

The Marginulinopsis collinsi zone extends from the top of the basal glauconitic sand of the Clearwater Formation to 165 feet below the top of the Formation. The faunal assemblage is calcareous and indicates a deepening of the Clearwater sea. The microfauna of this zone were found in the Gault Formation of England and in the Walnut Formation of Texas (Stelck, Wall, Bahan and Martin, 1956).

Megafossil studies led to similar conclusions. The ammonites of the Clearwater Formation (Subarcthoplites, Beudanticeras) are Middle Albian in age (Mellon and Wall, 1956, p. 11). It follows that the microfauna in the Upper McMurray Formation is older and can be considered as early Middle Albian. The following ammonite "zones" are recognized for the Lower Cretaceous of northern Alberta (McLearn, 1944). They are shown in descending order.

Lower Cretaceous	Neogastroplites, Posidonia nahwisi Gastroplites, Inoceramus cadottensis Subarcthoplites, Beudanticeras affine Elliptio biornatus

The stratigraphic interval represented by these zones ranges from the Upper Albian through the Middle Albian to the uppermost Lower Albian substages. The lower part of the Middle Albian Substage contains the following species, which are shown here in descending order (C.R. Stelck, pers. comm. and Mellon and Wall, 1956).

Subarcthoplites mcconnelli

Subarcthoplites irenense

Arcthoplites indicum

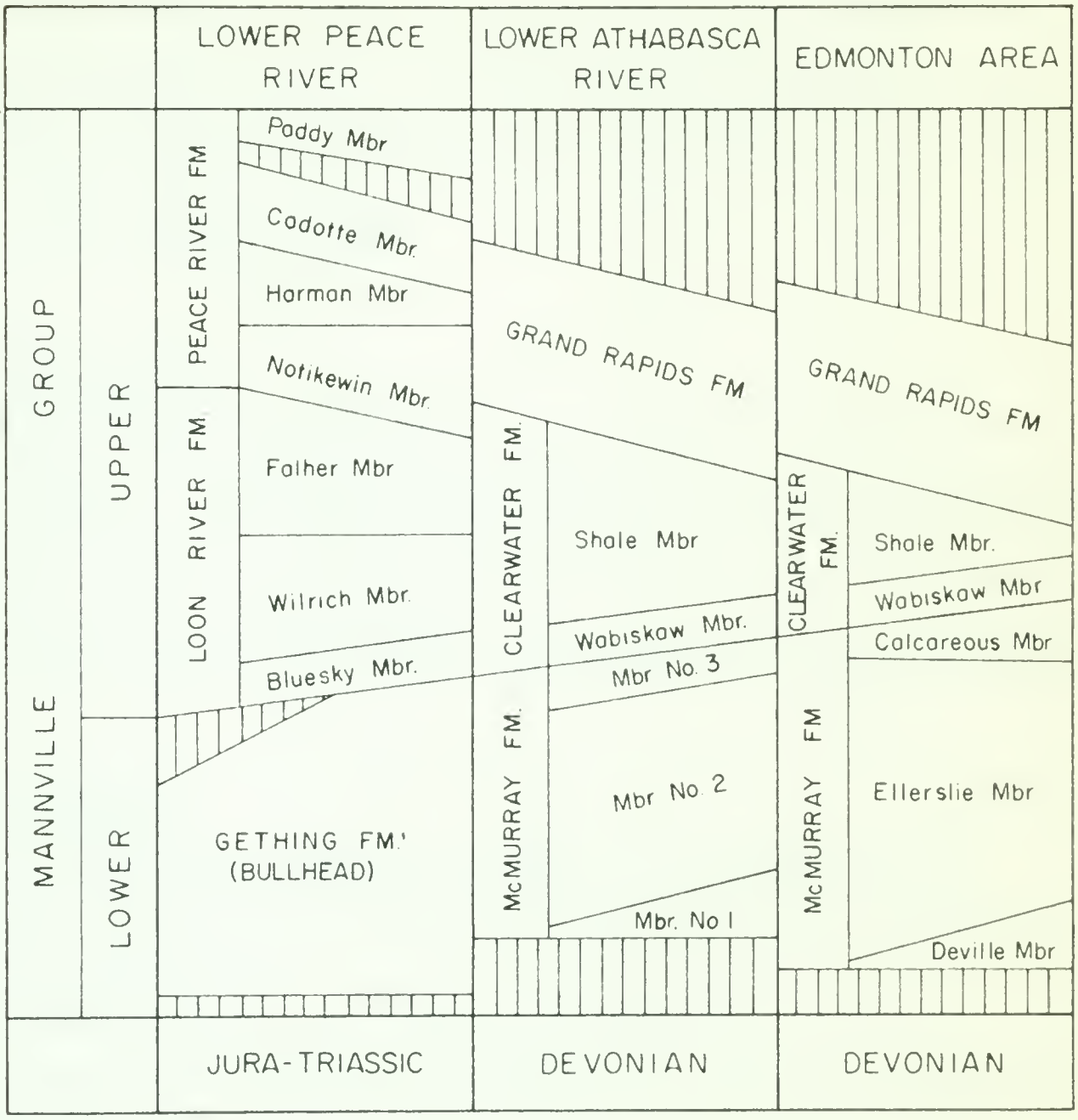
Cleoniceras cf. subbayleyi

Subarcthoplites mcconnelli fauna is characteristic of the Clearwater shale. Unio (Elliptio) biornatus fauna is found in the upper McMurray Formation and represents a slightly earlier age. The latter is believed to represent the brackish facies equivalent of the marine Arcthoplites indicum fauna. The upper part of the McMurray Formation is probably of early Middle Albian age.

Microfaunal studies indicate that the upper part of the McMurray Formation and the basal Clearwater Formation of the Athabasca area can be correlated with part of the Loon River Formation of the Peace River drainage area. Furthermore the upper part of the McMurray Formation and the basal Clearwater Formation are correlative with the Moosebar Formation of northeastern British Columbia and lie in the same stratigraphic position as the Wilrich Member of the Spirit River Formation of the Peace River region of Alberta. To the south the Cummings Member of the Mannville Formation in east-central Alberta is equivalent to the Clearwater Formation. The McMurray Formation is represented by the Dina Member of the Mannville Formation. Marine equivalents of the upper part of the McMurray Formation are the following sediments: Garbutt Formation (northeast British Columbia, Liard River drainage area), Sans Sault Group (Mackenzie River, Northwest Territories), unnamed shale beds (north Yukon) and upper Toroh Formation (north Alaska). In the Edmonton area the McMurray Formation consists of three members, the lowermost Deville Member (Badgley, 1952), the overlying Ellerslie Member (Hunt, 1950) and the uppermost "Calcareous" Member (Glaister, 1959). These members correspond to Carrigy's McMurray Members 1, 2 and 3 in the Fort McMurray area.

CORRELATION CHART OF THE MANNVILLE GROUP

(MODIFIED AFTER WILLIAMS, 1963)



CHAPTER THREE - PREPARATION TECHNIQUE

The Research Council of Alberta provided the writer with the core of the Socony-Vacuum Exploration Company Hole No. 27 (Sec. 27, Tp. 91, R. 10, W of 4th Mer., Alberta). The McMurray Formation and the basal Clearwater Formation in this core were sampled at intervals of approximately 10 feet. From the core, shaly partings were selected in sampling. In the basal McMurray Formation the core was poorly marked and therefore the corrected actual depth of the samples could deviate $\pm$ 5 feet from the indicated footage.

Mechanical maceration

Approximately 30 gms of material were selected for treatment from the individual samples. Inner portions of the core samples were selected to avoid possible contamination caused by the drilling mud. The material taken in this manner was crushed to pea-size (4-10 mm) or smaller and was thoroughly washed with distilled water.

Chemical maceration

The following basic phases were used in the maceration process:

Note: Following each phase, samples were washed three times, which included dilution with distilled water, centrifugation and decantation of supernatant liquid.

(1) Solution of carbonates: the samples were placed in 5 per cent HCl for approximately 1/2 hour. The time was increased by about 10 minutes if the samples were very calcareous.

(2) Solution of other mineral matter: the samples were covered with 52 per cent hydrofluoric acid and were digested for about 10-12 hours. The hydrofluoric acid was about three times the volume of the sample.

(3) Partial oxidization of organic matter: 50 per cent nitric acid or wet Schultze's solution was used. (The latter is made from 30 gm $KClO_3$, 600 ml HNO_3 (50%) and 300 ml H_2O). The time of digestion varied from 5 minutes to 15 minutes.

(4) Dispersal of humic acids: the sample was suspended in 5 per cent potassium carbonate for 5 to 10 minutes and as soon as the liquid had turned dark brown it was diluted with distilled water. This was followed by washing in distilled water until supernatant liquid was clear. The clay particles and grain fragments were removed from the sample by differential centrifuging. Supernatant liquids were checked under microscope before they were discarded.

Slide mounting technique

Channel samples were taken from the final residue to obtain a representative spectrum. Samples were stained with aqueous safranin O solution for 2-5 minutes. Corn syrup mounting medium (3 parts of corn syrup, 2 parts of H_2O and a few crystals of phenol to act as preservative) was used because it remains in viscous state and individual specimens may be rotated to change their orientation if necessary. The corn syrup was spread thinly and evenly on the slides to obtain a concentration of spore and pollen grains along a single plane. Five to ten slides were prepared for each sample, of which three were selected for detailed study.

Photomicrography

Photomicrographs were taken on a Leitz-Wetzlar Orthomat microscope camera. The exposure times were determined by an automatic control mechanism. Adox KB-14 35 mm negative film was used. The negatives were developed in Kodak Dextor 76 developer (D-76). The contrast on the negatives was regulated by the technique shown in Table 3. Printing and enlargement was done on a Durst 609 enlarger. Photographs were printed on Kodak Kodabromide F-4 single weight paper and they were developed in Kodak

Table 3

Contrast	D-76 part(s)	Water part(s)	Developing time in minutes
High	2	1	6
Medium	1	1	7
Low	1	2	7-8
Very low	1	3	10

Dextor 72 developer (D-72).

The relative size difference of the grains is indicated by a uniform x500 magnification on the plates.

Examination of the microscope slides

Three to five slides per sample were examined under low power (x125) by traversing them lengthwise along lines separated by a distance of 5 mm. The relative abundance of the various species has been estimated. (Abundant - present in large numbers; comon - present in reduced numbers; rare - present but not apparent.)

Table 4

LITHOLOGY AND TIMES OF TREATMENT OF SAMPLES

Socony-Vacuum Exploration Company Hole No. 27 (Sec. 27, Tp. 91, R. 10 W of 4th)

Sample No.	Drilling depth in feet	Lithology of samples	5% HCl minutes	52% HF hours	50% HNO_3 minutes	5% K_2CO_3 minutes	Formation
1	74	clay, dk gy, with 1/8" shaly partings	45	18.0	13	5	Clear-water Fm
2	84	as above	50	17.5	12	13	(Wabiskaw Mbr. lowe 8 feet)
3	101.10	clay, w. few small streaks sand and silt	40	17.5	8	5	
4	111	oil sand finely interbedded w. clay (clay taken)	30	15.0	5	8	
5	112-113	oil sand, low grade w. clay (clay taken)	30	15.0	30	15	
6	117	sst. very fine grained, hard, calcareous	10 hr.	24.0	20	30	
7	129	oil sand, br very fine grained, silty tr of cly (cly taken)	35	15.0	5	5	
8	132	as above	30	16.0	7	7	
9	142.6	oil sand w thin clay streaks, 10% clay (cly taken)	30	16.5	7 in HNO_3, 10 in Schultze's	17	
10	151	oil sand, v. fine grained, w few clay streaks, 10% clay (clay taken)	30	32.0	5	6	
11	187	clay with oil sand streaks	30	14.0	7	6	McMurray Formation
12	195	clay, silt & oil sand, v. fine grained, finely interbedded	30	15.0	5	5	
13	200	clay, silt, oil sands sst, calc, finely interbedded	30	15.0	7	5	
14	214	clay w. oil sand streaks, very fine grnd, silty	30	36.0	7	6	
15	219	cly w. oil sand streaks, v.f.g.	30	36.0	5	6	
16	225	clay w beds of oil sand, f.g.	30	15.0	7	6	
17	231	sst, v.f.g., hard calc	30	15.0	7	7	
18	239	clay w. streaks of oil sand, v.f.g.	30	15.0	11	7	
19	250	cly w oil sand streaks, vfg	30	16.0	7	7	
20	254	as above	30	16.0	7	7	
21	267	as above	30	16.0	8	7	
22	276	sst. hard, v.f.g., calc	30	15.0	7	7	
23	284	cly, lt. grey, calcareous	30	16.0	14	14	
24	290	clay, white, limey, part silty	30	15.0	7	7	Residual cly over Beaverhill Lake Fm.

CHAPTER FOUR - STRATIGRAPHIC PALYNOLOGY

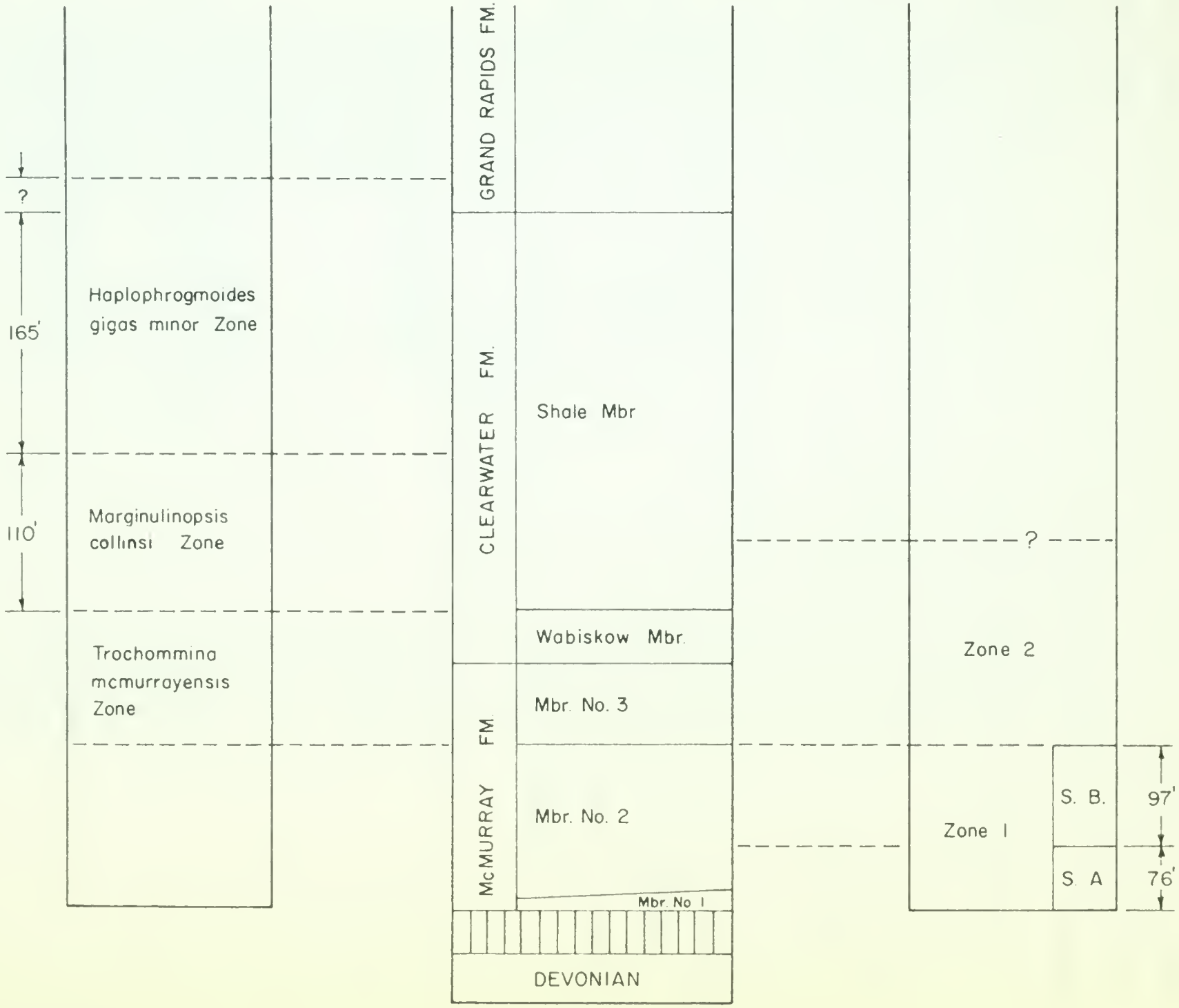
Results of Palynological Investigation

Microfloral examination of 24 subsurface samples from the McMurray and basal Clearwater Formations has yielded 111 distinct sporomorphae. Names are proposed for 5 new species. The microfloral assemblage is particularly diverse and well preserved throughout the section. The contamination of the assemblage by Paleozoic forms is negligible and only one Paleozoic specimen (Endosporites) was found, in the lowest part of the section, which was easily detected due to its dark staining. No sporomorphae were recovered from 2 of the 24 samples. (Fine to medium grained siltstones with minute shaly partings.) These two samples are located at depths of 142.6 and 101.10 feet. A systematic study of the sporomorphae provided sufficient information for a stratigraphic zonation of the section. At a depth of 151 feet a small, baculate, tricolpate grain was found which is the earliest undoubted angiosperm reported to date from Western Canada. No statistical study based on the changes in relative abundance of the species has been undertaken. However, an estimate of their relative abundance (abundant, common, rare) has been made and is shown in the lists given below.

Stratigraphic Distribution of the Sporomorphae

The stratigraphic distribution of the sporomorphae is given in Table A. The occurrences of the species are plotted against footage and the stratigraphical divisions are also indicated. The presence of each species at a given depth is indicated by a vertical line. The study provided sufficient information for zonation of the section. The section was subdivided into two zones. Zone 1 was further subdivided into two Subzones - Subzone A and Subzone B.

ZONATION BY MICROFAUNA AND MICROFLORA
IN THE SOCONY-VACUUM EXPLORATION COMPANY HOLE No. 27
Sec. 27, Tp. 91, Rge. 10W.4M., ALBERTA



LEGEND

S = Subzone

Microfloral Zone 2

This zone is characterized by an abundant marine microplankton assemblage. However, most of the sporomorphae, which made their first appearance at depths below this zone appear throughout this part of the section. The base of this zone is at a depth of 117 feet where the marine microplankton first appears. The presence of the marine microplankton suggests an open connection with the advancing Clearwater sea and marks the change of environment from brackish into lagoonal and later into shallow marine. Zone 2 probably extends into the upper part of the Shale Member of the Clearwater Formation. The top of this zone was not established because samples were studied only from the basal part of the Clearwater Formation. The base of Zone 2 is at the same depth as the base of the Trochammina mcmurrayensis Zone of Mellon and Wall in this well. This coincidence suggests the usefulness of microfloral and microfaunal approaches in establishing horizons of marine invasions. Seven species of marine microplankton belonging to 4 genera and marine cysts of uncertain affiliation are listed for this zone.

List of species making their first appearances at a depth of 117 feet.

(* species considered as index species)

* Paleoperidinium granulatum	abundant
* P. cretaceum	abundant
P. nudum	rare
Gonyaulax cf. G. jurassica	rare
* Hystrichosphaeridium albertense	abundant
* H. tubiferum	abundant
* Odontochitina operculata	abundant
* Marine cysts	abundant

Microfloral Zone 1

The base of Zone 1 is placed at the lowest part of the section and is at a depth of 290 feet. It lies in the residual clay overlying the Waterways Formation,

which is referred to in this thesis as McMurray Member No. 1. The base was placed at that horizon because the majority of the species make their first appearance there. Zone 1 extends up to 117 feet including the section prior to the first appearance of the marine microplankton assemblage.

The following species make their first appearance in McMurray Member No. 1 at a depth of 290 feet.

Sphagnumsporites antiquasporites	abundant
Lycopodiumsporites austroclavatidites	abundant
L. cerniidites	rare
L. clavatoides	abundant
L. marginatus	abundant
Osmundacidites wellmanii	common
Appendicisporites cooksonii	common
A. perplexus	common
A. trichacanthus var. dissectus	common
Cicatricosisporites dorogensis	abundant
Chomotriletes almegrensis	rare
Gleicheniidites circinidites	rare
G. senonicus	abundant
Cyathidites australis	rare
C. minor	abundant
Trilobosporites apiverrucatus	abundant
T. canadensis	abundant
T. trioreticulosus	common
Pilosisporites trichopapillosus	common
P. verus	abundant

Concavissimisporites parkinii	rare
C. variverrucatus	abundant
Deltoidospora hallii	common
D. psilostoma	common
D. junctum	rare
Hymenozonotriletes mesozoicus	abundant
Staplinisporites caminus	abundant
Aequitriradites variabilis	abundant
Rouseisporites reticulatus	abundant
R. triangularis	common
Cooksonites reticulatus	common
Januasporites spiniferus	abundant
Verrucosisporites asymmetricus	common
V. sp.	rare
Microreticulatisporites uniformis	rare
Laevigatosporites ovatus	common
Vitreisporites pallidus	rare
Alisporites cf. A. microsaccus	common
A. thomasii	rare
A. rotundus	common
Cedripites cretaceus	common
Podocarpidites ornatus	rare
P. minisculus	common
Classopollis classoides	rare
Exesipollenites tumulus	rare
Spheripollenites scabratus	rare

The following species make their first appearances in the McMurray Member No. 2.

- at a depth of 284 feet

Reticulatisporites castellatus	common
Appendicisporites degeneratus	rare
A. tricornitatus	common
Aequitriradites spinulosus	abundant
Cycadopites carpentieri	common

- at a depth of 276 feet

Lycopodiumsporites sp.	rare
Lycospora cretacea	abundant
Acanthotriletes varispinosus	common
Appendicisporites erdtmanii	common
Cicatricosisporites dorsostriatus	rare
C. irregularis	rare
Dictyotriletes granulatus	rare
D. southeyensis	rare
Lygodiumsporites sp.	rare
Concavissimisporites punctatus	abundant
C. singhi	rare
Januasporites reticularis	rare
Verrucosisporites rotundus	common
Schizosporis reticulatus	rare
Cycadopites formosus	common
Podocarpidites canadensis	common
cf. Brachisporium sp.	rare
Lygodiumsporites ambiperforatus	rare

Polyad grains	abundant
Lycopodiacidites cf. L. ambifoveolatus	rare

- at a depth of 267 feet

Todisporites minor	rare
Dictyotriletes pseudoreticulatus	rare
Cooksonites variabilis	common

An attempt was made to subdivide Zone 1 further into Subzone A and Subzone B.

Subzone A

Four species are restricted to this subzone		(first appearance) in feet
Tsugaepollenites radiostriatus	abundant	250
Lygodiumsporites ambiperforatus	rare	276
Polyad grains	abundant	276
Lycopodiacidites cf. L. ambifoveolatus	rare	276

The base of this subzone was placed at a drilling depth of 290 feet. The part of the section which lies below the first appearance of the four restricted species can be discriminated from the assemblage in Subzone B by recognizing in the latter those species which appear at higher horizons than the lower part of Subzone A. The top of Subzone A is placed at a depth of 214 feet. Above this depth the above mentioned four species were not recognized in the section.

Subzone B

The base of the subzone is placed at a depth of 214 feet and it extends up to 117 feet. This subzone in the section is recognized by the absence of abundant marine microplankton and by the absence of Subzone A index fossils and by the presence of

four species which have their first appearance at higher horizons than the lower part of Subzone A. These species are:

	First appearance in feet
Trilobosporites hannonicus	250
Cicatricosisporites mediostriatus	239
C. perforatus	250
Couperisporites complexus	231

These subzones probably have no significance outside of the type area, but they may be useful for local correlation.

Angiosperms

One undoubted angiosperm pollen grain was found at a drilling depth of 151 feet. Its small size may be responsible for some specimens being missed in examination of samples. This specimen was assigned to the species Tricolpopollenites micromunus Groot and Penny. This species is recorded from the Patapsco Formation of the Potomac Group of the eastern United States. Brenner (1963) suggests that the patapsco Formation is, in part, of late Albian age.

The first definite dicotyledonous pollen occurs in Central Russia (Bolkhovitina, 1953), New Zealand (Couper, 1960), and Portugal (see Brenner, 1963, p. 33) in the Albian Stage. The section studied in Portugal (Groot and Groot, unpublished manuscript) is primarily of continental sediments which were correlated by vertebrate and invertebrate fossils with the European Cretaceous Stages. No angiosperm pollen was found in the Aptian sediments and a single tricolpate grain was found in the Albian deposits. The late Albian and Early Cenomanian sediments yielded several dicotyledonous pollen. The above seems to confirm earlier than late Albian, possibly Middle Albian age for the McMurray Formation.

It is believed by some workers that microspores with an equatorial line or furrow along which a separation into two approximately equal parts takes place, belong to the angiosperms (e.g. Genus Schizosporis Cookson and Dettmann).

Polyad grains which show multicellular structure and which have pores suggest affiliation with angiosperms.

Results of palynological investigation from the Fort McMurray area compared to results of similar investigation from the Edmonton area.

Singh (1963) carried out an intensive palynological investigation of the Lower Cretaceous Mannville Group in Central Alberta. The area investigated by Singh (Edmonton area) is approximately 250 miles south of the Fort McMurray area.

In this section the majority of species make their first appearance in the McMurray Member 1. These include three species which were used by Singh to mark the base of the Clearwater Formation and the base of the upper part of the Grand Rapids Formation. The three species in question are shown below.

	Fort McMurray area (Vagvolgyi)	Edmonton area (Singh)
Species	First appearance	First appearance
Appendicisporites trichacanthus var. dissectus	base of McMurray Mbr 1	base of Clearwater Fm
A. perplexus	"	"
Januasporites spiniferus	"	base of U. Grand Rapids Fm.

Davies (1964) carried out a palynological study of six core samples from the Anglo-Home-C. and E. Fort Augustus No. 1 well (Lsd. 7, Sec. 29, Tp. 55, R. 21, W. 4th Mer.) as an assignment for partial credit in Geology 611 in the University of

Alberta. This is one of the three wells studied by Singh. Davies has found specimens belonging to Januasporites spiniferus in the upper part of the Clearwater Formation.

An opposite situation occurs in the case of Trilobosporites hannonicus, which makes its first appearance in the Edmonton area at the base of the Deville Member and in the Fort McMurray area above the base of the McMurray Member 2 at a drilling depth of 250 feet. The following chart shows the above mentioned anomaly.

	Fort McMurray area (Vagvolgyi)	Edmonton area (Singh)
Appendicisporites crimeansis	at 225 feet (61 feet above base of McMurray Mbr 2)	base of Deville Mbr.
Cicatricosisporites mediostriatus	at 239 feet (47 feet above base of McMurray Mbr 2	"
Trilobosporites hannonicus	at 250 feet (36 feet above base of McMurray Mbr 2	"

The two different types of anomalies suggest that the first appearance of the species is ecologically controlled in the two sections. Therefore, in order to eliminate the possibility of misinterpretation, the concept of first appearance and entrance level ought to be critically evaluated in terms of ecology.

CHAPTER FIVE - SUMMARY AND CONCLUSIONS

Twenty-four subsurface samples were selected from the core of the Socony-Vacuum Exploration Company Hole No. 27 (Sec. 27, Tp. 91, R. 10 W. of 4th Mer.) and their microfloral content was systematically examined.

The investigation yielded 102 distinct species belonging to 45 genera of spores and pollen grains, eight species of marine microplankton representing five genera and one species of megaspore of uncertain affiliation.

Based on the distribution of the sporomorphae, the section studied in the well was divided into two zones.

Zone 2 is in brackish to salt water facies that extends through top of the McMurray from the base of Member No. 3 to the base of the Clearwater Shale Member. That is, the zone embraces Member No. 3 of the McMurray, the Wabiskaw Member and the basal part of the Shale Member of the Clearwater Formation. It probably extends into the upper part of the Clearwater shale but this has not been investigated. Eight species of marine microplankton are restricted to this zone. The base of this zone coincides with the base of the Trochammina mcmurrayensis zone of Mellon and Wall. The sudden and abundant appearance of the marine microplankton above a drilling depth of 117 feet suggests an open connection with the advancing Clearwater sea and marks the change of environment from brackish into lagoonal and later into shallow marine.

The base of Zone 1 is at a drilling depth of 290 feet, which is the bottom of the section studied. Zone 1 extends up to a drilling depth of 117 feet. That is, Zone 1 includes Members No. 1 and No. 2 of the McMurray Formation.

Of the total assemblage 46 species make their first appearance at the base of Zone 1, 5 additional species appear first at a drilling depth of 284 feet (base of McMurray Mbr No. 2), 20 species at a drilling depth of 276 feet and 3 species at a

drilling depth of 267 feet. Zone 1 was further subdivided into Subzone A and Subzone B. The sbuzones might be utilized for local correlation, but their validity has to be confirmed from other nearby sections.

No further refinement of age could be obtained from this well. However this investigation confirms a general Lower to Middle Albian position for the McMurray Formation.

The McMurray Member No. 1 of the type area is a homotaxial equivalent of the Deville Member of the Edmonton area, but seems to be very closely related bio-stratigraphically with Member No. 2, whereas Singh seemed to conclude that the Deville in the Edmonton area might include beds much earlier than Albian.

McMurray Member No. 2 of type area seems to be correlative both bio-stratigraphically and rock-stratigraphically with the Ellerslie Member of Central Alberta.

McMurray Member No. 3 of type area is correlative with the Calcareous Member of Central Alberta, but the biofacies of the McMurray area seems to indicate a greater salinity than that of the Edmonton region. If homotaxy is involved it is not apparent from the palynological studies.

The correlation of the Wabiskaw Member and the base of the Clearwater shale from the McMurray area with the Wabiskaw Member and Shale Member of the Edmonton area is validated.

However, there are a few anomalies in the palynological correlation.
(1) Three index species of Singh, two of which appear first at the base of the Clearwater Formation and one at the base of the Upper Grand Rapids Formation in the Edmonton area, make their first appearance at the base of the McMurray Formation in the present study.
(2) Three index species of Singh which appear first at the base of the Deville Member in the Edmonton area, make their first appearance from 36 to 61 feet above the base of McMurray Member No. 2. The two types of anomalies suggest that the first appearance of the species is ecologically controlled in the two sections.

The microflora suggests that during the deposition of the lower part of the McMurray Formation the lower lands were covered by ferns and pteridosperms. The conifer and cycad flora favors higher and drier surfaces and they probably covered the land east and southeast of the McMurray area. The microflora indicates warm humid climate in the area during McMurray and basal Clearwater times.

CHAPTER SIX - SYSTEMATIC DESCRIPTIONS

Taxonomic approach

A systematic approach similar to that of Singh (1963) has been adopted in this work. The main features of this taxonomic approach are as follows:

1. Potonie's (1956, 1958, and 1960) systematic account has been used at the generic and specific levels only.
2. Only organ genera and form genera has been used. Organ genera have been assigned to their respective natural families.
3. The principles of priority and type method have been followed.

FAMILY SPHAGNACEAE

Genus Sphagnumsporites Raatz, 1937

DIAGNOSIS: Trilete; laesurae simple, may or may not reach the equator; size small; equatorial outline triangular with convex sides; corners rounded, sometimes arched; exine smooth, relatively thick and rigid.

Sphagnumsporites antiquasporites (Wilson and Webster) Pocock, 1962

Plate 1, figure 1

1946 Sphagnum antiquasporites Wilson and Webster, Am. J. Bot. 33(4), pp. 271-278.
For synonymy 1947, 1953 and 1959 see Singh, 1963, p. 107.
Pocock, 1962, Palaeontographica, B, 111, p. 32, pl. 1, figs. 1-3.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, unpub. Ph.D. thesis, p. 107, pl. 1, fig. 1.
Brenner, 1963, The spores and pollen of the Potomac Group of Maryland, State of Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, pp. 41-42, pl. 4, fig. 1.

DISTRIBUTION: Upper Jurassic, Cretaceous and Tertiary. Abundant.

REMARKS: For description see Singh, 1963, p. 107. The spores of this type were found from a depth of 290 feet up to 74 feet. The specimen figured is from a depth of 111 feet.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology,
Palynological Coll.
Slide: Soc. 27-111-1; Co-ord: 117.4, 70.5

Sphagnumsporites psilatus (Ross) Couper, 1958

Plate 1, figure 2

1949 Triletes psilatus Ross, Bull. Geol. Inst. Upsala 34, p. 32, pl. 1, fig. 12
For synonymy 1958 see Singh, 1963, p. 108.
Pocock, 1962, Palaeontographica, B, 111, p. 32, pl. 1, fig. 4.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 108, pl. 1, fig. 2.

REMARKS: For description see Singh, 1963, p. 108. The specimens found here have a smaller average size than the ones reported by Singh and their size ranges from 27 microns to 33 microns. The spores of this type were found from a depth of 214 feet up to 74 feet. The specimen figured is from a depth of 214 feet.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology,
Palynological Coll.
Slide: Soc. 27-84-3 Co-ord: 125, 71

FAMILY LYCOPODIACEAE

Genus Lycopodiumsporites Thiergart ex Delcourt and Sprumont, 1955

DIAGNOSIS: Trilete; equatorial outline subtriangular; laesurae may reach equator; distal surface reticulate with regular muri; muri are sometimes high; proximal surface unsculptured.

Lycopodiumsporites austroclavatidites (Cookson) Pocock, 1962

Plate 1, figures 3-4

1953 Lycopodium austroclavatidites Cookson, Aust. J. Bot. 1, p. 469, pl. 2, fig. 35.
For synonymy 1953, 1958, 1959, see Singh, 1963, p. 109.
Pocock, 1962, Palaeontographica B, 111, p. 33, pl. 1, figs. 5-6.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 109-110, pl. 1, figs. 3-4.
Brenner, 1963, The Spores and Pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, p. 44, pl. 5, fig. 3

DISTRIBUTION: Jurassic and Lower Cretaceous. Common.

REMARKS: For description see Singh, 1963, pp. 109-110. The spores of this type were found from a depth of 290 feet up to 74 feet. Equatorial diameter of the spores ranges from 27 to 44 microns. (Singh's size range: 30 to 40 microns.) The specimens figured are from depths of 254 and 117 feet.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology, Palynological Coll.
Slides: Soc. 27-117-3; Soc. 27-254-8; Co-ord: 128.3, 44.5 122.6, 27.8

Lycopodiumsporites cerniidites (Ross) Delcourt and Sprumont, 1955

Plate 1, figure 5

1949 Lycopodium cerniidites Ross, Bull. Geol. Inst. Upsala, 34, p. 30, pl. 1, figs. 1,2.
For synonymy 1955 see Singh, 1963, p. 110.
Pocock, 1962, Palaeontographic, B, 111, p. 33, pl. 1, figs. 7-8.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 110, pl. 1, figs. 5-6.

DISTRIBUTION: Jurassic and Cretaceous. Rare.

REMARKS: For description see Singh, 1963, p. 110. The spores reported here have a size range between 30 and 60 microns. The ones which were originally described by Ross had a size range between 24 and 29 microns. Singh reported a size range between 30 to 60 microns. The spores of this type were found from a depth of 290 feet up to 74 feet. The specimens figured are from depths of 214 and 112-113 feet.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-214-9 Co-ord: 120, 34

Lycopodiumsporites marginatus Singh, 1963

Plate 1, figure 8

DISTRIBUTION: Barremian? to Middle Albian. Rare.

REMARKS: For description see Singh, 1963, p. 111. Equatorial diameter (including the membraneous zone) 45 to 68 microns. Singh reported a size range between 50 to 60 microns. This species is present throughout the whole section.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-219-8 Co-ord: 120, 26

Lycopodiumsporites clavatoides Couper, 1958

Plate 1, figures 6-7

1958 Lycopodiumsporites clavatoides Couper, British Mesozoic microspores and pollen grains, a systematic and stratigraphic study, Palaeontographica, Abt. B, Bd. 103, Lief, 4-6, pp. 75-179, pls. 15-31, 11 text figs., 12 tab., Stuttart.

DISTRIBUTION: Jurassic and Lower Cretaceous.

REMARKS: For description see Couper, 1958, p. 132. The specimens found appear to fit Couper's description very well. The spores of this type were found in abundance from a depth of 290 feet up to 74 feet.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-267-7 Co-ord: 121.3, 23.9

Lycopodiumsporites sp. A

Plate 1, figure 9

DISTRIBUTION: Barremian? to Middle Albian. Very rare.

REMARKS: For description see Singh, 1963, p. 112. The specimen figured is from a depth of 225 feet.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-225-7 Co-ord: 127.1, 35.2

Genus Lycospora Schopf, Wilson and Bentall, 1944

DIAGNOSIS: Trilete; trilete mark distinct and simple, extends almost to the margin; cingulate; equatorial outline nearly cicular to sub-triangular; central body laevigate, infragranulate or granulate.

Lycospora cretacea Pocock, 1962

Plate 1, figure 10

1962 Lycospora cretacea Pocock, Palaeontographica B, 111, p. 34, pl. 1, figs.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 114, pl. 1, fig. 16.

DISTRIBUTION: Lower Cretaceous.

REMARKS: For description see Singh, 1963, p. 114. Description exactly as for Lycospora cretacea except that the exine is ornamented with scattered low verrucae in the center of the grain and it becomes spinulose toward the periphery.

The specimens figured are from depths of 225 and 219 feet.

REPOSITORY: University of Alberta, Edmonton, Dept. Geology
Palynological Coll.
Slides: Soc. 27-225-6 Co-ord: 107.5, 66

Genus Lycopodiacidites Couper, 1953, emend Potonie, 1956

Lycopodiacidites cf. L. ambiforeolatus Brenner, 1963

Plate 8, figures 6-7

1963 Lycopodiacidites ambifoveolatus Brenner, The Spores and Pollen of the Potomac Group of Maryland. State of Maryland, Dept. of Geology, Mines and Water Resources. Bull. 27, p. 63, pl. 17, figs. 1, 2.

REMARKS: For description see Brenner, 1963, p. 63. This species appears to be similar to that described by Brenner, but the size is somewhat larger, the commissure is bordered by a wider lip and the margin of the spore is not pitted. In

this section the maximum diameter of this species ranges from 48 to 60 microns whereas in the Potomac Group it ranges from 48 to 50 microns. Lycopodiacidites intraverrucatus is also similar but has a circular shape.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-225-6 Co-ord: 125.5, 34
Soc. 27-254-2 110, 67.7

Lycopodiacidites baculatus Pocock, 1962

Plate 1, figure 14

1962 Lycopodiacidites baculatus Pocock, Palaeontographica B, 111, pp. 33-34, pl. 1, figs. 10-11.

DISTRIBUTION: Oxfordian to Middle Albian?

REMARKS: For description see Pocock, 1962, pp. 33-34. Pocock in his study found this species restricted to the upper Vanguard Formation. However, in the Fort McMurray area it reappears in the McMurray Member 2.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-254-7 Co-ord: 120.5, 43.4

Genus Reticulatisporites (Ibrahim) Schoph, Wilson and Bentall, 1944

DIAGNOSIS: Trilete or alete microspores; equatorial outline circular to subcircular; exine coarsely and often irregularly reticulate; aside from the coarse ornamentation the exoexine may have a variously smooth, punctate, or finely reticulate texture.

Reticulitasporites castellatus Pocock, 1962

Plates 1,2, figures 15,1

1962 Reticulatisporites castellatus Pocock, Palaeontographica B, 111, p. 35, pl. 1, fig. 14.

DISTRIBUTION: Lower Mannville and stratigraphic equivalents:
Upper Neocomian to Middle Albian

REMARKS: For description see Pocock, 1962, p. 35. The total diameter of these grains agree very closely with that recorded by Pocock, 1962. (Total diameter 36-89 microns.) However, two specimens were found with total equatorial diameter of 130 and 135 microns. It appears that it may be possible to split this species into two at a later date on the basis of total equatorial diameter, but in this section it is not common enough to warrant such a subdivision.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-214-5 Co-ord: 124.1, 33.1
Soc. 27-254-7 116.4, 63.6

FAMILY SELAGINELLACEAE

Genus Acanthotriletes (Naumora, 1937? 1939) ex Potonie and Kremp, 1954

DIAGNOSIS: Trilete; ciliate; spines closely crowded, attenuate, longer than twice their diameter.

Acanthotriletes varispinosus Pocock, 1962

Plate 1, figure 11

1962 Acanthotriletes varispinosus Pocock, Palaeontographica B, 111, p. 36, pl. 1, figs. 18-20.
Singh, 1963, Palynology of the Mannville Group (lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 115, pl. 1, figs. 17-18.

DISTRIBUTION: Lower Cretaceous. Rare.

REMARKS: For description see Singh, 1963, p. 115. The specimens figured are from depths of 276 and 200 feet.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-276-9 Co-ord: 124, 21.3

FAMILY OSMUNDACEAE

Genus Osmundacidites Couper, 1953

DIAGNOSIS: Trilete, laesurae about 3/4 of the radius of spore; equatorial outline circular, but frequently folded; exine ornamented with granular papillate structures.

Osmundacidites wellmanii Couper, 1953

Plate 1, figure 12

1953 Osmundacidites wellmanii Couper, N.Z. Geol. Surv. Pal. Bull. 22, p. 20, pl. 1, fig. 5.
Pocock, 1962, Palaeontographica B, 111, p. 35, pl. 1, fig. 15.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 117, pl. 1, fig. 20.

DISTRIBUTION: Jurassic and Lower Cretaceous. Common.

REMARKS: For description see Singh, 1963, p. 117. Spores of this type were found from a depth of 290 feet up to 74 feet. The specimens figured are from depths of 290 and 276 feet.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-276-7 Co-ord: 125.7, 62.8

Genus Todisporites Couper, 1958

DIAGNOSIS: Trilete; laesurae simple, more than 2/3 radius of spore; equatorial outline more or less circular; exine thin, smooth to finely scabrate.

Todisporites minor Couper, 1958

Plate 1, figure 13

1958 Todisporites minor Couper, Palaeontographica B, 103, p. 135, pl. 16, figs. 9,10
Pocock, 1962, Palaeontographic B, 111, p. 36, pl. 1, fig. 16.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 119, pl. 1, fig. 22.
Brenner, 1963, The Spores and Pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, p. 45, pl. 6, fig. 1

DISTRIBUTION: Middle Jurassic to Lower Cretaceous. Rare.

REMARKS: For description see Singh, 1963, p. 119. The specimen figured is from a depth of 267 feet.

REPOSITORY: University of Alberta. Dept. of Geology
Palynological Coll.
Slide: Soc. 27-267-9 Co-ord: 116.9, 23.8

FAMILY SCHIZAEACEAE

Genus Appendicisporites Weyland and Krieger, 1953

DIAGNOSIS: Trilete; exine two-layered with a thick ektexine layer; equatorial outline more or less triangular; apical appendices short and conical or very long in which case they equal or exceed the equatorial diameter of the central body; ektexine covered with broad partially branching ridges more or less parallel to the equatorial sides of the spore; the ridges in the polar regions slightly bent towards the pole.

Appendicisporites tricornitatus Weyland and Greifeld, 1953

Plate 2, figure 2

1953 Appendicisporites tricornitatus Weyland and Greifeld, Paleontographica, B, 95, p. 43, pl. 11, fig. 52.
Pocock, 1962, Palaeontographica B, III, p. 38, pl. 2, figs. 24-26.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 120, pl. 2, fig. 1.
Brenner, 1963, The Spores and Pollen of the Potomac Group Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, p. 47, pl. 7, fig. 3.

DISTRIBUTION: Cretaceous. Abundant.

REMARKS: For description see Singh, 1963, p. 120. The specimens figured are from depths of 225 and 117 feet.

REPOSITORY: University of Alberta. Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-117-1 Co-ord: 124.8, 59

Appendicisporites crickmayii Pocock, in press

In press Appendicisporites crickmayii Pocock, Grana Palyn., vol. 5
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 121-122, pl. 2, figs. 2-3.

DISTRIBUTION: Barremian? to Middle Albian

REMARKS: For description see Singh, 1963, pp. 121-122. The specimens figured are from depths of 276 and 187 feet.

Appendicisporites erdtmanii Pocock, in press

Plate 2, figures 3-4

in press Appendicisporites erdtmanii Pocock, Grana Palyn., vol. 5
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 123-124, pl. 2, figs. 5-7.

DISTRIBUTION: Barremian? to Middle Albian. Common.

REMARKS: For description see Singh, 1963, pp. 120-124. The size range assigned to this species by Pocock (50-55 microns) is extended and established as going from 40 to 55 microns. This species appears throughout the section. The specimens figured are from depths of 225 and 214 feet.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-225-7 Co-ord: 128.5, 23
Soc. 27-276-8 108, 59.5

Appendicisporites cooksonii (Balme) Pocock, in press

Plate 2, figure 5

1939 Anemia mitriformina Korzhenevskaya, Report VSEGEI, Leningrad
For synonymy 1957, 1958, 1961 and in press see Singh, 1963, pp. 124-125
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 124-125, pl. 2, figs. 8-10.

DISTRIBUTION: Callovian to Albian.

REMARKS: For description see Singh, 1963, p. 125. This species occurs only in the lower part of the section up to the top of McMurray Member 2. The specimens figured are from depths of 290 and 250 feet.

REPOSITORY: University of Alberta. Edmonton. Dept. of Geology
Palynological Coll.
Slide: Soc. 27-276-8 Co-ord: 117.9, 60.8

Appendicisporites crimensis (Bolkhovitina) Pocock, in press

Plate 2, figure 6

1961 Anemia crimensis Bolkhovitina, Acad. Sci. USSR, Trans. Geol. Inst. vol. 40, p. 55, pl. 15, fig. 8, pl. 17, fig. 7.
For synonymy - in press - see Singh, 1963, p. 126.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 126, pl. 2, figs. 11-12.

DISTRIBUTION: Hauterivian to Albian.

REMARKS: For description see Singh, 1963, p. 126. This species occurs all through the section. The specimens figured are from depths of 254 and 187 feet.

REPOSITORY: University of Alberta, Edmonton, Dept of Geology
Palynological Coll.
Slide: Soc. 27-231-7 Co-ord: 112, 18.3

Appendicisporites trichacanthus (Maljavkina) var. dissectus (Markova) Singh, 1963

Plate 2, figures 8-9

1961 Anemia trichantha (Maljavkina) var. dissecta Markova, Trans. of the All Union Petr. Sci. Res., Geol. Surv. Inst., vol. 177, p. 73, pl. 18, figs. 3a-6.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 130, pl. 3, figs. 1-6.

DISTRIBUTION: Albian to Cenomanian. Very rare.

REMARKS: For description see Singh, 1963, p. 130. In the Fort McMurray area several specimens of this species were found. In Central Alberta only a single specimen of this species was recorded by Singh. The specimens assigned by the author to this species show some variations. One group of the specimens - called Group A - is similar in general form to the one described by Singh but is smaller in size and does not have very pronounced appendices.

Singh's specimen	Equatorial diameter including appendices = 97 microns
Group A	" = 56-67 microns

The other group of specimens - called Group B - shows a size range from 90 to 97 microns. The appendices in this group are pronounced and the specimens are very similar to the one described by Singh. There is a possibility of subdivision on the basis of measurements of appendices and variations in size of the test. Unfortunately, the specimens are too scarce in this section to justify such a subdivision. The specimens figured are from depths of 276, 239 and 225 feet.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-239-8 Co-ord: 109, 59.3
Soc. 27-225-5 126.9, 23.5

Appendicisporites unicus (Markova) Singh, 1963

Plate 2, figure 10

1961 Anemia unica Markova, Trans. of the All Union Petr. Sci. Res., Geol. Surv. Inst., vol. 177, p. 79, pl. 20, figs. 3a-b.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 133, pl. 4, figs. 4-6.

DISTRIBUTION: Albian to Cenomanian. Very rare.

REMARKS: For description see Singh, 1963, p. 133. The specimen figured is from a depth of 250 feet.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-250-4 Co-ord: 122, 33.6

Appendicisporites perplexus Singh, 1963

Plate 2, figure 11

1963 Appendicisporites perplexus Singh, 1963 (in press). Unpub. Ph.D. thesis, University of Alberta, Edmonton

DISTRIBUTION: Middle Albian

REMARKS: For description see Singh, 1963, pp. 135-136. The specimens assigned to this species are identical to those described by Singh. In central Alberta this species makes its appearance abruptly at the base of the Clearwater Formation and Singh used it as an important stratigraphic marker. However, in the Fort McMurray area, which is approximately 250 miles northeast of the Edmonton area, this species makes its appearance in the lower part of the McMurray Formation. The diameter of this species in the Fort McMurray area ranges from 33 to 43 microns with an average of 40 microns. These dimensions most closely compare with Singh's measurements.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-117-3 Co-ord: 113.9, 54

Appendicisporites degeneratus Thiergart, 1953

Plate 2, figure 12

1953 Appendicisporites degeneratus Thiergart, Paleontographica 95B, p. 55
Pl. 14, fig. 4.
For synonymy 1953 see Pocock, Palaeontographica, vol. 111, Pt. B, p. 37
Pocock, 1962, Palaeontographica, B, 111, p. 37, pl. 1, figs. 21-22.

DISTRIBUTION: Upper Jurassic to Lower Cretaceous.

REMARKS: For description see Pocock, Palaeontographica, vol. 111, Pt. B, p. 37. The specimens assigned to this species are similar to A. degeneratus Thiergart, but differ from it in the smaller size. The equatorial diameter of the holotype from the Cenomanian

of Germany is 80 microns, while the diameter of this species in the Fort McMurray area ranges from 45 to 63 microns. Pocock reported this species first from the western Canada Plains. Pocock in his latest work (in press) dealing with the Upper Mannville strata of the Saskatoon area, Saskatchewan, reported A. degeneratus again, however, his figure resembles most closely A. perplexus Singh.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-231-3 Co-ord: 117.1, 70

Genus Cicatricosisporites Potonie and Gelletich, 1933

DIAGNOSIS: Trilete; exine two layered and sculptured with muri or ridges of uniform width and height; canaliculate to cicatricose; the muri are more or less parallel to the equator. Equatorial outline regularly crenate, with no tendency to thicken at the apices.

Cicatricosisporites dorogensis Potonie and Gelletich, 1933

Plate 3, figure 1

1933 Cicatricosisporites dorogensis Potonie and Gelletich, Sitz. Ber. Ges. Naturf. Freunde, Berlin, p. 522, pl. 1, figs. 1-5.
For synonymy 1951, 1953, 1956 and 1961 see Singh, 1963, p. 139.
Pocock, 1962, Palaeontographica, B, 111, pp. 39-40, pl. 2, figs. 35-36, pl. 3, figs. 37-41.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 139, pl. 6, fig. 1.
Brenner, 1963, The Spores and Pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, p. 49, pl. 8, fig. 4.

DISTRIBUTION: Purbeck to Tertiary. Abundant.

REMARKS: For description see Singh, 1963, p. 139.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-276-4 Co-ord: 122.1, 20.4

Cicatricosisporites dorsostriatus (Bolkhovitina) Singh, 1963

Plate 3, figure 2

1956 Anemia dorsostriata, Bolkhovitina, Trans. Geol. Inst. Acad. Sci. U.S.S.R., no. 2, p. 60, pl. 7, figs. 95a-b.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 140, pl. 6, figs. 2-4.

DISTRIBUTION: Middle Jurassic to Albian. Very rare.

REMARKS: For description see Singh, 1963, p. 140. Forms found in this section are slightly smaller than the specimens described by Singh from the Lower Cretaceous of Central Alberta. In the Fort McMurray area the equatorial diameter ranges from 43 to 53 microns and in Central Alberta from 48 to 55 microns. Width of the girdle is approximately 4 microns and the number of ribs seems to be ten.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-214-9 Co-ord: 129.4, 58

Cicatricosisporites irregularis n. sp.

Plate 3, figures 3-4

DESCRIPTION: Trilete spore; laesurae reaching or nearly reaching the equator; outline in polar view triangular with slightly convex sides and moderately rounded corners; exine is about 1.5 to 2 microns thick. On the proximal face a few (2-4) irregularly developed sinuous ribs about 2.5 microns wide and about 1.5 microns high are running more or less parallel to the equator. Ribs are spaced at intervals of 1 to 2 microns. A triangular area around the proximal pole is smooth. The distal face is striate with sinuous discontinuous irregularly thickened ribs about 1.2 microns high and about 2 microns wide, spaced at intervals of 1 to 2 microns. The irregularly thickened ribs under high focus appear as elongate aligned verrucae. Color orange yellow.

SIZE RANGE: Max. diameter 51-62 microns
Holotype 51.3 microns

REMARKS: This spore looks superficially like Anemia cf. mandioccana Rud. (Trans. of the All Union Petr. Sci. Res., Geol. Surv. Inst., vol. 177, pl. XXVIII, fig. 24). However, the latter does not show the unornamented triangular area around the proximal pole.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Holotype - Soc. 27-276-8 Co-ord: 117, 23.9
Paratype - Soc. 27-276-8 115.8, 37

Cicatricosisporites perforatus (Baranov, Nemkova, Kondratiev) Singh, 1963

Plate 3, figure 5

1957 Anemia perforata Baranov, Nemkova, Kondratiev. Impression of leaves and spectrum of spores and pollen of a horizon with flora from Mikhailovska Formation from the River Kem, p. 202, pl. 2, fig. 22.
For synonymy 1961 see Singh, 1963, p. 141.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 141, pl. 6, figs. 5-7.

DISTRIBUTION: From Barremian? to Turonian. Abundant at the base of the McMurray Mbr. No. 2.

REMARKS: For description see Singh, 1963, p. 141. In the Fort McMurray area this species has an equatorial diameter ranging from 43 to 62 microns. This approximates the dimensions reported by Singh (48-58 microns).

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-250-4 Co-ord: 121.5, 65.8

Cicatricosisporites mediostriatus (Bolkhovitina) Pocock, (in press)

Plate 3, figure 6

1961 Pelletieria mediostriata Bolkhovitina, Acad. Sci. U.S.S.R., Trans. Geol. Inst., vol. 40, p. 66, pl. 19, figs. 3a-b, pl. 21, figs. 1a-c.
For synonymy--in press--see Singh, 1963, p. 142.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 142, pl. 6, fig. 8.
Pocock, in press, Grana Palyn., vol. 5.

DISTRIBUTION: Hauterivian to Turonian. Common.

REMARKS: For description see Singh, 1963, p. 143. The equatorial diameter of the specimens assigned to this species in the Fort McMurray area ranges from 40 to 57 microns, while the equatorial diameter reported by Singh from central Alberta ranges from 40 to 50 microns.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-239-8 Co-ord: 114.3, 61.9

Cicatricosisporites sp. A

Plate 3, figure 7

DESCRIPTION: Trilete; laesurae reaching the equator; commissures slightly raised; equatorial outline rounded triangular with convex sides; proximal surface ornamental by 3 to 4 sets of ribs running parallel to the side of the grain; distal surface ornamented by 8 to 10 ribs disposed obliquely to one side of the spore; a single row of holes present at the distal ribs.

SIZE RANGE: maximum diameter 33.8 microns.

REMARKS: This species has not been formally described as only one specimen was found.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-225-7 Co-ord: 108, 28.9

Cicatricosisporites sp. B

Plate 3, figure 8

DESCRIPTION: Trilete; laesurae about 3/4 of the spore radius, commissures raised, ektexine thick and ornamented with ribs 1.5 to 2 microns wide, spaced about 1-1.5 microns apart; on the proximal surface ribs run parallel to the sides of the grain; at or near to the apices lobes are present indicating a weakness in the ektexine.

SIZE RANGE: Maximum diameter 40.5 microns.

REMARKS: This species has not been formally described as only one specimen was found.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-719-7 Co-ord: 171.8, 43.5

Genus Chomotriletes (Naumova, 1937) Naumova, 1953

DIAGNOSIS: Trilete mark very faint or absent; equatorial outline irregularly circular to broadly subtriangular; very characteristic ornamentation consisting of concentric ridges on at least one face; these ridges may or may not be continuous.

Chomotriletes almegrensis Pocock, 1962

Plate 3, figure 9

1962 Chomotriletes almegrensis Pocock, Palaeontographica B, 111, p. 38, pl. 2, figs. 27-29.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 146, pl. 7, fig. 7.

DISTRIBUTION: Barremian? to Middle Albian. Very rare.

REMARKS: For description see Singh, 1963, p. 146. Most of the specimens were found in the lower part of the section. Equatorial diameter ranges from 38 to 52 microns.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-284-8 Co-ord: 111.8, 26

Genus Schizaeoisporites Potonie, 1951

DIAGNOSIS: Monolete spores; cicatrilose to canaliculate exine; laesura has a ridge on either side.

Schizaeoisporites eocenicus (Selling) Potonie, 1956

Plate 3, figure 10

1934 Sporites dorogensis Potonie, Arb. Inst. Paleob. Petr. Brennsteine 4, pp. 40, 41, pl. 1, fig. 22.
For synonymy 1944, 1949, 1951, 1952 and 1956 see Singh, 1963, p. 148.
Pocock, 1962, Palaeontographica, B, 111, p. 41, pl. 3, fig. 45.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 148-149, pl. 7, figs. 8-9.

DISTRIBUTION: Lower Cretaceous to Eocene. Rare.

REMARKS: For description see Singh, 1963, pp. 148-149. In the Fort McMurray area the length of this species ranges from 47 to 67 microns and the width ranges from 29 to 38 microns, while from Central Alberta Singh reported on average length of 65 microns and average breadth of 38 microns.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-284-3 Co-ord: 126,36

Schizaeoisporites phaseolus Delcourt and Sprumont, 1955

Plate 3, figure 11

1955 Schizaeoisporites phaseolus Delcourt and Sprumont, Mem. Soc. Belge. Geol. n.s. 5, pp. 46-47.
Pocock, 1962, Palaeontographica, B, 111, p. 41, pl. 3, fig. 44.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 149, pl. 7, figs. 10-11.

DISTRIBUTION: Lower Cretaceous.

REMARKS: For description see Singh, 1963, p. 149. Forms found in this section have an average length of 64 microns and an average breadth of 46 microns. These specimens are slightly larger than the ones reported by Singh from Central Alberta (av. length 48 microns, av. breadth 28 microns). The size of the specimens found in this section compare most closely with those found in Europe.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 29-195-8 Co-ord: 120.4, 49.5

Genus Dictyotriletes (Naumova, 1937) Potonie and Kremp, 1955

DIAGNOSIS: Trilete; equatorial outline sub-triangular to sub-circular; proximal face flat, levigate; distal face reticulate, strongly convex, the mesh-structure of the exine surface is composed of low and flat muri, luming shallow.

Dictyotriletes pseudoreticulatus (Couper) Pocock, 1962

Plate 3, figure 12

1958 Klukisporites pseudoreticulatus Couper, Palaeontographica B, 103, p. 138, pl. 19, figs. 8-10.

1962 Dictyotriletes pseudoreticulatus (Couper) Pocock, Palaeontographica, B, 111, p. 41, pl. 3, figs. 46-47.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 150-151, pl. 7, figs. 12-13.

DISTRIBUTION: Upper Jurassic to Lower Cretaceous.

REMARKS: For description see Singh, 1963, pp. 150-151. A common spore throughout the section.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology Palynological Coll.
Slide: Soc. 27-267-10 Co-ord: 124, 61.7

Dictyotriletes granulatus Pocock, 1962

Plate 4, figure 1

1962 Dictyotriletes granulatus Pocock, Palaeontographica B, 111, p. 42, pl. 3, figs. 48-50.

DISTRIBUTION: Neocomian by Pocock (probably Middle Albian not Neocomian).

REMARKS: For description see Pocock, 1962, p. 42, The specimens assigned to this species are identical to those described by Pocock but their size range is somewhat different. The equatorial diameter of Pocock's specimens ranges from 54 to 60 microns, whereas the specimens found in this study have a size range from 46 to 55 microns.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-276-12 Co-ord: 110.2, 50.3

Dictyotriletes southeyensis Pocock, 1962

Plate 4, figure 2

1962 Dictyotriletes southeyensis Pocock, Palaeontographica B, 111, p. 42, pl. 3, figs. 51-54.

DISTRIBUTION: Neocomian to Middle Albian?

REMARKS: For description see Pocock, 1962, p. 42.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-276-12 Co-ord: 113.9, 63.9

Genus Lygodiumsporites (Potonie, Thomson and Thiergart, 1950) Singh, 1963

DIAGNOSIS: Trilete microspores, laesurae extending from 1/2 to 4/5 of the spore radius, equatorial outline rounded triangular, apices broadly rounded, exine smooth to sub-granulose.

Lygodiumsporites sp.

Plate 4, figure 3

DISTRIBUTION: Middle Albian

REMARKS: For description see Singh, 1963, p. 158. The specimens assigned to this species are identical to those described by Singh as Lygodiumsporites sp. B., but their size is somewhat smaller. In the Fort McMurray area the equatorial diameter ranges from 48 microns to 54 microns, while from Central Alberta Singh reported 85 microns for the equatorial diameter. This species has not been formally described as only a few specimens assignable to it were found.

Lygodiumsporites sp. appears to be almost identical with Sporites adrieunis Potonie f. mesozoicus Thiergart, 1949. However Lygodiumsporites sp. has a very

finely granulate exine and along the broadly rounded apices has a distinct thickening.

It is also very close to Hymenophyllumsporites deltoida Rouse, 1957 but the ribbon-like lists bordering the laesurae, which are diagnostic of the latter, are lacking.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-276-10 Co-ord: 117.3, 27

Lygodiumsporites ambiperforatus n. sp.

Plate 4, figures 4-6

DESCRIPTION: Trilete; laesurae simple slits, somewhat raised, reaching or nearly reaching the equator. The raised extremity of laesurae may or may not bifurcate. Equatorial outline triangular with strongly convex sides and broadly rounded apices. Exine very finely granulate and at places perforate. The ektexine on the proximal surface near the equatorial outline shows a thinning pattern which appears as small elongated perforations, with the long axis directed towards the proximal pole. This thinning is rather short and their appearance is most pronounced around the equator. Color light yellow.

SIZE RANGE: Equatorial diameter 52 to 58 microns (7 specimens). Holotype 56.5 microns. Exine 3 to 3.5 microns.

REMARKS: This species is easily recognised by its distinctive perforation on the proximal surface, which is the most diagnostic feature of it. This species makes its first appearance at 276 feet level in this section. One specimen, along its periphery, shows small pieces of flaked-off exine, which possibly indicates an almost completely destroyed zona. The evidence is not convincing, however. The presence of zona would put this species to the genus Hymenozonotriletes.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: (Holotype) Soc. 27-231-7 Co-ord: 111, 45
(Paratypes) Soc. 27-219-8 111, 67.9
Soc. 27-225-6 128, 33

FAMILY GLEICHENIACEAE

Genus Gleicheniidites (Ross, 1949) Delcourt and Sprumont, 1955

DIAGNOSIS: Trilete; laesurae simple, reaching or almost reaching the equator; equatorial outline triangular; apices sharply arcuate; sides usually concave to straight; exine smooth.

Gleicheniidites circinidites (Cookson, 1953) Brenner, 1963

Plate 4, figure 7

1953 Gleichenia circinidites Cookson, Austr. Jour. Bot., Vol. 1, no. 3, pp. 464-465, pl. 1, figs. 5,6.
For synonymy 1953 and 1961, see Brenner, 1963, p. 53.
Brenner, 1963, The Spores and Pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, p. 53, pl. 11, figs. 4-5.

REMARKS: For description see Cookson, 1953, pp. 464-465 and Brenner, 1963, p. 53. These specimens appear to be identical to Cookson's and Brenner's specimens. Acute corners and a tendency for the equatorial thickening to extend around the apices are the diagnostic features of this species.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-276-8 Co-ord: 126.5, 31.3

Gleicheniidites senonicus Ross, 1949

Plate 4, figure 8

1949 Gleicheniidites senonicus Ross, Bull. Geol. Inst. Upsala 34, p. 31, pl. 1, figs. 2 and 4.
For synonymy 1957 and 1961 see Singh, 1963, p. 160.
Pocock, 1962, Palaeontographica B, 111, pp. 42-43, pl. 3, figs. 55-56.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 160-161, pl. 8, figs. 8-9.
Brenner, 1963, The Spores and Pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources Bull. 27, p. 53, pl. 11, fig. 6.

DISTRIBUTION: Jurassic and Cretaceous.

REMARKS: For description see Singh, 1963, pp. 160-161. G. senonicus can be distinguished from G. circinidites by its greater curvature and by the equatorial thickening, which is confined to the sides.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-267-9 Co-ord: 126.2, 44

FAMILY CYATHEACEAE

Genus Cyathidites Couper, 1953

DIAGNOSIS: Trilete; laesurae simple, always over 2/3 of the radius of spore; equatorial outline triangular; apices broadly rounded; sides concave; proximal face is slightly convex whereas the distal face is markedly convex; exine psilate.

Cyathidites australis Couper, 1953

Plate 4, figure 10

1953 Cyathidites australis Couper, N.Z. Geol. Surv. Pal. Bull. 22, p. 27, pl. 2, fig. 11.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 162-163, pl. 8, fig. 12.

DISTRIBUTION: Jurassic and Lower Cretaceous

REMARKS: For description see Singh, 1963, pp. 162-163. This spore is rare, but it was found throughout the section.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-254-8 Co-ord: 117, 29.1

Cyathidites minor Couper, 1953

Plate 4, figure 9

1953 Cyathidites minor Couper, N.Z. Geol. Surv. Pal. Bull. 22, p. 28, pl. 2, fig. 13.
Pocock, 1962, Palaeontographica, B, 111, p. 43, pl. 4, figs. 57-58.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 163, pl. 8, fig. 13.
Brenner, 1963, The Spores and Pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, pp. 53-54, pl. 11, fig. 7.

DISTRIBUTION: Jurassic and Cretaceous

REMARKS: For description see Singh, 1963, p. 163, An abundant spore.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-84-3 Co-ord: 125.1, 71.5

FILICALES - INCERTAE SEDIS

Genus Trilobosporites (Pant, 1954 nom. nud.) ex. Potonie, 1956

DIAGNOSIS: Trilete; equatorial outline triangular; sides more or less concave; apices rounded with thickened exine.

Trilobosporites hannonicus (Delcourt and Sprumont) Potonie, 1956

Plates 4,5, figures 11,1

1955 Concavisporites hannonicus Delcourt and Sprumont, Mem. Soc. Belg. Geol. n.s. 4(5), p. 24, pl. 2, fig. 3
For synonymy 1956, see Singh, 1963, p. 164
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 164-165, pl. 8, figs. 14-15.

DISTRIBUTION: Barremian? to Aptian?

REMARKS: For description see Singh, 1963, pp. 164-165. This species was recorded from the lowermost part of the section.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-250-3 Co-ord: 125.2, 66.1
Soc. 27-219-8 118.9, 33

Trilobosporites apiverrucatus Couper, 1958

Plate 5, figures 2-3

1958 Trilobosporites apiverrucatus Couper, Palaeontographica B, 103, p. 142, pl. 21, fig. 11.
Pocock, 1962, Palaeontographica, B, 111, pp. 43-44, pl. 4, figs. 59-60.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 165-166, pl. 8, figs. 16-18.

DISTRIBUTION: Barriasian to Middle Albian.

REMARKS: For description see Singh, 1963, pp. 165-166. This species can be distinguished from Trilobosporites trioreticulosus by its verrucate apices. (Also recorded by Pocock, 1962).

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-250-8 Co-ord: 122.1, 61.1
Soc. 27-219-8 116.4, 68.5

Trilobosporites canadensis Pocock, 1962

Plate 5, figures 5-6

1962 Trilobosporites canadensis Pocock, Palaeontographica B, 111, p. 44, pl. 4, figs. 63-68.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 167, pl. 8, figs. 19-20.

DISTRIBUTION: Barremian to Aptian.

REMARKS: For description see Singh, 1963, p. 167. This species is extremely variable with regard to ornamentation. It may be very subdued, or may be heavily ornamented with large bulbous verrucae covering the entire spore surface.

REPOSITORY: University of Alberta, Edmonton, Dept of Geology
Palynological Coll.
Slides: Soc. 27-276-11 Co-ord: 118, 18.3
Soc. 27-276- 8 123, 29.7

Trilobosporites trioreticulosus Cookson and Dettmann, 1958

Plate 5, figure 4

1958 Trilobosporites trioreticulosus Cookson and Dettmann, Proc. Roy. Soc. Victoria, new ser., vol. 70, pt. 2, p. 109, pl. 17, figs. 1-3.
For synonymy 1961, see Singh, 1963, p. 168
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 168, pl. 9, figs. 1-2.

DISTRIBUTION: Barremian? to Albian.

REMARKS: For description see Singh, 1963, p. 168. The equatorial diameter of these grains agree quite closely with those recorded by Singh, however, a few grains had somewhat smaller diameter than those of Singh's. The equatorial diameter in Central Alberta ranges from 55 to 80 microns.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-219-7 Co-ord: 119.2, 69.3

Trilobosporites sp.

Plate 5, figure 7

DESCRIPTION: Trilete; equatorial outline triangular; sides slightly concave to slightly convex; laesurae somewhat raised and about 3/4 of radius of spore; wide margo present. Polar ornamentation is composed only of small verrucae; apices rounded; largest verrucae is found at the apices; generally the size of verrucae is increasing toward the periphery. Exine 6-7 microns thick.

SIZE RANGE: Equatorial diameter 73 microns.

REMARKS: This species has not been formally described as only one specimen was found.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-254-7 Co-ord: 121.1, 36.1

Genus Pilosisporites Delcourt and Sprumont, 1955

DIAGNOSIS: Trilete; laesurae do not reach the equator completely; equatorial contour triangular; sides slightly convex, straight or concave; ornamentation echinate; fimbriae, capilli or short thin spines cover all or large parts of the surface.

Pilosisporites trichopapillosus (Thiergart) Delcourt and Sprumont, 1955

Plate 6, figures 2-3

1949 Sporites trichopapillosus Thiergart, Palaeontographica B, 89, p. 22, pl. 4,5, fig. 18.
For synonymy 1955 and 1961 see Singh, 1963, p. 170.
Pocock, 1962, Palaeontographica, B, 111, p. 45-46, pl. 4, fig. 70.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, p. 170, pl. 9, fig. 4.
Brenner, 1963, The Spores and Pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources, p. 67, pl. 20, fig. 3.

DISTRIBUTION: Purbeck to Middle Albian.

REMARKS: For description see Singh, 1963, p. 170. This species makes its first appearance in the lowest part of the section.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-195-8 Co-ord: 111.9, 64.9
Soc. 27-195-8 120.3, 62.8

Pilosisporites verus Delcourt and Sprumont, 1955

Plate 6, figure 1

1955 Pilosisporites verus Delcourt and Sprumont, Mem. Soc. Belg. Geol., n.s. 4(5), p. 35, pl. 4, fig. 1.
For synonymy 1961 see Singh, 1963, p. 171.

1962 Pilosisporites verus Delcourt and Sprumont, in Pocock, p. 45, pl. 4, fig. 69

DISTRIBUTION: Lower Cretaceous

REMARKS: For description see Singh, 1963, p. 171.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-195-9 Co-ord. 118.9, 69

Genus Concavissimisporites (Delcourt and Sprumont, 1955) emend, Delcourt, Dettman and Hughes, 1963

DIAGNOSIS: Microspores trilete; outline triangular with concave to almost straight sides. Exine of uniform thickness (inclusive of sculpture), subgranulose to verrucose, granules or verrucae more or less uniformly developed and evenly distributed over entire spore surface.

Concavissimisporites punctatus (Delcourt and Sprumont) Brenner, 1963

Plate 6, figure 4

1955 Concavisporites punctatus Delcourt and Sprumont, Mem. Soc. Belg. Geol. n.s. 4(5), p. 25, pl. 1, fig. 8, pl. 2, fig. 2.
For synonymy 1955, 1955, 1958, 1962, 1963 and in press see Singh, 1963, p. 172.
Brenner, 1963, The Spores and pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, p. 59, pl. 14, fig. 6.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 172, pl. 9, figs. 6-7.

DISTRIBUTION: Berriasian to Aptian.

REMARKS: For description see Singh, 1963, p. 172. This species makes its first appearance in the lowest part of the section.

REPOSITORY: University of Alberta, Dept. of Geology, Edmonton
Palynological Coll.
Slide: Soc. 27-250-7 Co-ord: 108.9, 50.9

Concavissimisporites parkinii (Pocock) Singh, 1963

Plate 6, figures 5

1962 Concavisporites parkinii Pocock, Palaeontographica B, 111, p. 46, pl. 4, fig. 71
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 175-176, pl. 9, fig. 8.

DISTRIBUTION: Barremian? to Aptian.

REMARKS: For description see Singh, 1963, pp. 175-176. This species makes its first appearance in the lowest part of the section.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-290-3 Co-ord: 127.3, 45.4

Concavissimisporites variverrucatus (Couper) Brenner, 1963

Plate 6, figure 6

1958 Concavisporites variverrucatus Couper, Palaeontographica B, 103, p. 142, pl. 22, figs. 4, 5.
For synonymy 1961 see Singh, 1963, p. 176.
Brenner, 1963, The spores and pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, p. 59, pl. 14, fig. 4.
Singh, 1963, The palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 176, pl. 9, figs. 9-11.

DISTRIBUTION: Bajocian to Middle Albian.

REMARKS: For description see Singh, 1963, p. 176. This species makes its first appearance in the lowest part of the section.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-239-7 Co-ord: 118.9, 70.1

Concavissimisporites singhi, n. sp.

Plate 6, figures 7-8

DESCRIPTION: Trilete; equatorial outline triangular; sides very concave, apices well rounded; laesurae not reaching margin of the equator. Exine is two-layered; ektexine (a thick outer layer), and endexine (a thin inner layer). The thickness of the exine is somewhat bigger in the interradial region. Both the proximal and distal surfaces have a rather undulose appearance.

SIZE RANGE: Equatorial diameter 35 to 46 microns. (6 specimens)
Holotype 46.2 microns.
Thickness of exine 3 to 5 microns (6 specimens).

REMARKS: This species was first recorded from Central Alberta by Singh, 1963, but has not been formally described because only one specimen was found.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-214-7 Co-ord: 122.9, 64.8
(Holotype) Soc. 27-129-5 119, 42.9

Genus Deltoidospora (Miner, 1935) Potonie, 1956

DIAGNOSIS: Trilete, laesurae simple, more than 2/3 of spore radius; equatorial outline triangular with rounded apices; sides mostly straight, but may be slightly concave to convex, exine smooth.

Deltoidospora hallii Miner, 1935

Plate 6, figure 9

1935 Deltoidospora hallii Miner, Am. Mid. Nat., 16(4), p. 618, pl. 24, fig. 7
Pocock, 1962, Palaeontographica, B, 111, p. 48, pl. 5, fig. 81.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 178, pl. 9, figs. 13-14.
Brenner, 1963, The spores and pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, p. 61, pl. 15, fig. 5.

DISTRIBUTION: Mesozoic

REMARKS: For description see Singh, 1963, p. 178.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-112-113-1 Co-ord: 119, 62.3

Deltoidospora psilostoma Rouse, 1959

Plate 6, figure 11

1959 Deltoidospora psilostoma Rouse, Micropaleontology 5(3), p. 311, p. 2, figs. 7,8.
Pocock, 1962, Palaeontographica, B, 111, p. 48, pl. 5, figs. 82-83.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 179, pl. 9, fig. 15.

DISTRIBUTION: Bathonian to Upper Cretaceous

REMARKS: For description see Singh, 1963, p. 179.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-129-5 Co-ord: 119, 27.5

Deltoidospora junctum (Kara Mursa) Singh, 1963

Plate 6, figure 10

1956 Cibotium junctum Kara Mursa in Bolkhovitina, Acad. Sci. U.S.S.R., Trans. Inst. Geol., No. 2, p. 37, pl. 3, figs. 25a-e.

DISTRIBUTION: Upper Jurassic to Lower Cretaceous.

REMARKS: For description see Singh, 1963, p. 180. Singh's interpretation, that the distal exine has a thickening perpendicular to the apices along which the exine is folded on itself, is shown clearly on Plate 6, figure 10.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-290-8 Co-ord: 11.2, 25.3

Genus Hymenozonotriletes (Naumova, 1937) ex Naumova, 1953

DIAGNOSIS: Trilete microspores with a membranous zona; equatorial outline subtriangular; exine covered with cones or spines.

Hymenozonotriletes mesozoicus Pocock, 1962

Plate 6, figure 12

1962 Hymenozonotriletes mesozoicus Pocock, Palaeontographica B, 111, 1-3, p. 49, pl. 5, figs. 85, 86.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 182, pl. 9, figs. 17-19.

DISTRIBUTION: Barremian? and Aptian.

REMARKS: For description see Singh, 1963, p. 182. This species shows measurements within the range recorded by Singh. (Equatorial diameter from 45 to 55 microns. Equatorial diameter including zona from 50 to 62 microns.)

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-219-7 Co-ord: 126, 35.3

Genus Couperisporites Pocock, 1962

DIAGNOSIS: Trilete, rigid trilete mark reaching the zona and extending almost to the equatorial margin and sometimes bifurcating at the tips; proximal exine thin, smooth to granulate; distal surface of the central body with a narrow outer zone thickened with rugulate ornaments just inside the zona, and a wide inner area with polyzonal based hollow bosses each carrying a short thick spine.

Couperisporites complexus (Couper) Pocock, 1962

Plate 7, figure 1

1958 Cingulatisporites complexus Couper, Palaeontographica B, 103, p. 145, pl. 24, figs. 1, 2.
For synomymy 1962, see Singh, 1963, p. 185.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 185, pl. 10, figs. 4-10.

DISTRIBUTION: Barremian to Middle Albian.

REMARKS: For description see Singh, 1963, p. 185. This species makes its first appearance in the lower part of the section.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-231-6 Co-ord: 124.8, 57.3

Genus Staplinisporites Pocock, 1962

DIAGNOSIS: Trilete; well developed raised commissures, equatorial outline rounded-triangular; proximal exine thin, smooth to granulose; distal surface ornamented by concentric and radial bands of exinal thickening, the distal pole carries a thickened granulose boss which may become detached leaving a thin granulose area.

Staplinisporites caminus (Balme) Pocock, 1962

Plate 7, figure 2

1957 Cingulatisporites caminus Balme, C.S.I.R., Australia, Ref. TC 25, p. 27, pl. 5, figs. 62, 63.
For synonymy 1962 see Singh, 1963, p. 186.

1963 Cingulatisporites caminus Balme, in Brenner 1963, p. 57, pl. 13, fig. 5
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 186, pl. II, figs. 1-4

DISTRIBUTION: Upper Jurassic and Lower Cretaceous.

REMARKS: For description see Singh, 1963, pp. 186-187. This species makes its first appearance in the lowest part of the section and is abundant in the McMurray Formation.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-276-8 Co-ord: 126.9, 29.3

Genus Taurocusporites Stover, 1962

DIAGNOSIS: Spores radial; trilete; equatorial outline convexly triangular to sub-circular. Proximal surface smooth or ornamented; distal surface trizonate. Trilete distinct; lips weakly developed to prominent, smooth or segmented.

Taurocusporites minor Singh, 1963

Plate 7, figure 3

1963 Taurocusporites minor Singh, Palynology of the Mannville Group (Lower (Cretaceous) Central Alberta, Unpub. Ph.D. thesis, University of Alberta, Edmonton, p. 191 (in press).

DISTRIBUTION: Barremian? to Middle Albian.

REMARKS: For description see Singh, 1963, p. 191. This species can be distinguished by its distinct trilete mark with wide lips, and the pits surrounding the second thickened zone.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-84-3 Co-ord: 115.2, 50

Genus Aequitriradites (Delcourt and Sprumont, 1955) Singh, 1963

DIAGNOSIS: Trilete microspores with a membranous zona. Laesurae distinct or only faintly represented especially towards the proximal pole. Exine entire or perforated distally. When perforated, the opening is formed as the result of a natural exinous breakdown about the distal pole. Sculptural elements various.

Aequitriradites spinulosus (Cookson and Dettmann) Cookson and Dettmann, 1961

Plate 7, figure 4

1961 Cirratriradites spinulosus Cookson and Dettmann, Proc. Roy. Soc. Victoria, n.s. 70(2), p. 113, pl. 18, fig. 9.
For synonymy 1961 and 1961, see Singh, 1963, p. 193.

1963 Cirratriradites spinulosus Cookson and Dettmann in Brenner, 1963, p. 43, pl. 4, figure 4; plate 5, figure 1.
Pocock, 1962, Palaeontographica, B, 111, p. 52, pl. 6, figs. 95-97.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta. Unpub. Ph.D. thesis, p. 193, pl. 11, figs. 12-13.

DISTRIBUTION: Cretaceous.

REMARKS: For description see Singh, 1963, p. 193. Singh recorded a size range of 55 to 90 microns for the equatorial diameter (including the zona). In this section a few smaller specimens were found and the equatorial diameter (including the zona) ranges from 43 to 90 microns.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-231-7 Co-ord: 126,22

Aequitriradites variabilis Pocock, 1962

Plate 7, figure 5

1961 Aequitriradites varialilis Pocock, Palaeontographica B, 111, pp. 51, 52, pl. 6, figs. 98-100.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 194-195, pl. 11, figs. 14-15.

DISTRIBUTION: Barremian? to Middle Albian.

REMARKS: For description see Singh, 1963, pp. 194-195. This species makes its first appearance in the lowest part of the section.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-267-10 Co-ord: 113.2, 28

Genus Rouseisporites Pocock, 1962

DIAGNOSIS: Alete or trilete; equatorial outline convexly triangular with narrow equatorial flange which may be reduced to an apical flange in some species, laesurae indistinct and in some specimens may be absent altogether, when present they are terminated by extensions of the equatorial flange; in some species, the spore body has extensions only in the apical portions; apical extensions may be penetrated by holes which may or may not visibly penetrate the central body; some species have a Y-shaped distal ornamentation.

Rouseisporites reticulatus Pocock, 1962

Plate 7, figure 6

1962 Rouseisporites reticulatus Pocock, Palaeontographica B, 111, p. 53, pl. 7, figs. 101-105.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 196, pl. 11, figs. 16-17.

DISTRIBUTION: Barremian? to Albian.

REMARKS: For description see Singh, 1963, p. 196.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-200-8 Co-ord: 125.1, 37.9

Rouseisporites triangularis Pocock, 1962

Plate 7, figures 7

1962 Rouseisporites triangularis Pocock, Palaeontographica B, 111, p. 54, pl. 7, figs. 110-111
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D thesis, pp. 198-199, pl. 11, fig. 19.

DISTRIBUTION: Barremian? to Albian.

REMARKS: For description see Singh, 1963, pp. 198-199. The specimens figured show the distal exine marked by a distinct Y-shaped ridge which alternates with the faint proximal trilete mark.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-231-7 Co-ord: 122.1, 36.9

Genus Cooksonites Pocock, 1962

DIAGNOSIS: Alete or rarely trilete; exine thick, usually internally striate, covering the entire proximal surface of the central body, extending to the distal surface beyond the equator and thinning over an approximately circular area surrounding the distal pole.

Cooksonites variabilis Pocock, 1962

Plate 7, figures 8-9

1962 Cooksonites variabilis Pocock, Palaeontographica B, 111, pp. 54, 55, pl. 7, figs. 112-117.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis.

DISTRIBUTION: Barremian? and Aptian.

REMARKS: For description see Singh, 1963, p. 200. This species makes it first appearance in the lowest part of the section. The equatorial diameter ranges from 60 to 70 microns, which agrees with the range recorded by Singh, 1963. However, one

specimen was found at the horizon of 214 feet, which has an equatorial diameter of 102 microns. This specimen clearly shows the exposed central body over an approximately circular area surrounding the distal pole which is ornamented by a meshwork of polyzonal plates. This specimen to the author's knowledge can be assigned with certainty to this species. As only one specimen was found the size range has not been formally extended.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-214-9 Co-ord: 108.8, 41
Soc. 27-225-7 114.8, 53.9

Cooksonites reticulatus Pocock, 1962

Plate 8, figures 1-2

1962 Cooksonites reticulatus Pocock, Palaeontographica B, 111, pp. 55, 56, pl. 8, figs. 118-120.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 201, pl. 12, figs. 4-7.

DISTRIBUTION: Barremian? and Aptian.

REMARKS: For description see Singh, 1963, p. 201. In this section the equatorial diameter ranges from 54 to 87 microns, whereas from central Alberta Singh recorded a range from 55 to 72 microns.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-214-8 Co-ord: 128.3, 36.5

Genus Januasporites (Pocock, 1962) Singh, 1963

DIAGNOSIS: Alete microspores; often showing the rudiments of a non-functional tetrad scar on the ektexine of the proximal contact zone; exine two-layered; ektexine thin, absent over a more or less circular area on the distal face, the endexine is also thin in this circular area; ektexine forms a narrow hyaline zona

around the central body; equatorial outline rounded-triangular, endexine smooth to scabrate; both proximal and distal ektexine have either a reticulate, corrugate or spinose ornamentation.

Januasporites spiniferus Singh, 1963

Plate 8, figures 3-4

1963 Januasporites spiniferus Singh, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, University of Alberta, Edmonton, pp. 202-203 (in press).

DISTRIBUTION: Middle Albian.

REMARKS: For description see Singh, 1963, pp. 202-203. Singh recorded that the ektexine forms a 2 to 5 microns wide hyaline zona around the central body and the total equatorial diameter ranges from 55 to 60 microns. Specimens found in this section have a somewhat different size range. Thirteen specimens were measured and it was found that six of them have a total equatorial diameter ranging from 43 to 67.5 microns and the width of the hyaline zona ranges from 0.5 to 5.4 microns. Seven specimens have a total equatorial diameter ranging from 62 to 81 microns and the width of the zone ranges from 8 to 10 microns. The specimens with the wider zona are ornamented with somewhat longer and wider spines. Specimens belonging to both of these size groups can be found through the whole section. Although there is some variation in the size and width of the zona, specimens found in this section seem to group themselves into the above mentioned species.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-276-3 Co-ord: 129.1, 34.5
Soc. 27-214-3 125.4, 33.3

Januasporites reticularis Pocock, 1962

Plate 8, figure 5

1962 Januasporites reticularis Pocock, Palaeontographica B, 111, p. 56, pl. 8, figs. 121-123.

DISTRIBUTION: Lower Cretaceous.

REMARKS: For description see Pocock, 1962, p. 56.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-239-9 Co-ord: 121, 71.2

Genus Verrucosisporites (Ibrahim, 1932) Potonie and Kremp, 1954

DIAGNOSIS: Trilete; circular to sub-circular in equatorial outline; exine covered with thickly crowded broad based warts which are more or less irregularly rounded or sometimes arcuate.

Verrucosisporites asymmetricus (Cookson and Dettmann) Pocock, 1962

Plate 9, figure 1

1958 Apiculatisporites asymmetricus Cookson and Dettmann, Proc. Roy. Soc. Victoria, n.s. 70(2), p.100, pl. 14, fig. 11.
For synonymy 1962 see Singh, 1963, p. 204.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 204, pl. 13, figs. 1-2.

DISTRIBUTION: Barremian? to Albian

REMARKS: For description see Singh, 1963, p. 204. This species makes its first appearance in the lowest part of this section.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-219-9 Co-ord: 121.5, 57.3

Verrucosisporites rotundus Singh, 1963

Plate 9, figure 2

1963 Verrucosisporites rotundus Singh; Palynology of the Mannville Group (Lower Cretaceous) Central Alberta. Unpub. Ph.D. thesis, University of Alberta, Edmonton, pp. 205-206 (in press).

DISTRIBUTION: Barremian? and Aptian.

REMARKS: For description see Singh, 1963, pp. 205-206. In the Fort McMurray area the equatorial diameter ranges from 43 to 53 microns, whereas in Central Alberta from 45 to 50 microns.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-254-6 Co-ord: 112.9, 45.9

Verrucosisporites sp.

Plate 9, figure 3

DISTRIBUTION: Middle Albian

REMARKS: For description see Singh, 1963, p. 206. Equatorial diameter ranges from 45 to 51 microns whereas in Central Alberta equatorial diameter is 51 microns. This species has not been formally described as only three specimens assignable to it were found.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-276-12 Co-ord: 125.4, 51.8

Genus Microreticulatisporites (Knox, 1950) Potonie and Kremp, 1954

DIAGNOSIS: Trilete; equatorial outline triangular to circular; margin crenate to undulating; exine extrareticulate with small lumina whose diameters are not more than 6 microns, the muri are sometimes imperfect, branched, and of variable height.

Microreticulatisporites uniformis Singh, 1963

Plate 9, figure 4

1963 Microreticulatisporites uniformis Singh. Palynology of the Mannville Group (lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, University of Alberta, Edmonton, pp. 207-208.

DISTRIBUTION: Barremian? to Middle Albian.

REMARKS: For description see Singh, 1963, p. 208.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-225-5 Co-ord: 117.8, 69.5

Genus Laevigatosporites (Ibrahim, 1933) emend. Schopf, Wilson and Bentall, 1944

DIAGNOSIS: Monolete; outline smooth; laevigate to infrapunctate; equatorial outline ovoid; meridional outline bean-shaped; exine always without sculpture; monolete mark straight.

Laevigatosporites ovatus Wilson and Webster, 1946

Plate 8, figure 8

1946 Laevigatosporites ovatus Wilson and Webster, Am. J. Bot., 33(4), pp. 271-278.
For synonymy 1957 see Singh, 1963, p. 210.
Pocock, 1962, Palaeontographica B, 111, p. 58, pl. 8, figs. 130-133.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 210, pl. 13, figs. 9-11.

DISTRIBUTION: Upper Jurassic and Cretaceous to Eocene.

REMARKS: For description see Singh, 1963, p. 210.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-267-9 Co-ord: 113.7, 22.6

Genus Schizosporis Cookson and Dettmann, 1959

DIAGNOSIS: Microspores medium to large, with an equatorial line or furrow along which a separation into two approximately equal parts takes place.

Schizosporis reticulatus Cookson and Dettmann, 1959

Plate 9, figure 5

1959 Schizosporis reticulatus Cookson and Dettmann, Micropaleo., vol. 5, no. 2, pp. 213, 214, pl. 1, figs. 1-4.
Pocock, 1962, Palaeontographica, B, 111, p. 76, pl. 13, fig. 202.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 212-213, pl. 13, fig. 14.
Brenner, 1963, The spores and pollen of the Potomac Group of Maryland, Dept. of geology, Mines and Water Resources Bull. 27, pp. 96-97, pl. 42, fig. 4, pl. 43, figs. 1,2.

DISTRIBUTION: Neocomian to Albian and Cenomanian?

REMARKS: For description see Singh, 1963, p. 212. A rare spore.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-239-9 Co-ord: 111.9, 24

Schizosporis cooksoni Pocock, 1962

Plate 9, figure 6

1962 Schizosporis cooksoni Pocock, Palaeontographica B, 111, p. 76, pl. 13, figs. 197-198.

DISTRIBUTION: Upper Jurassic and Middle Albian.

REMARKS: For description see Pocock, 1962, p. 76.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-111-6 Co-ord: 127.9, 23.9

Schizosporis parvus Cookson and Dettmann, 1959

Plate 9, figure 7

1959 Schizosporis parvus Cookson and Dettmann, Micropaleo., vol. 5, no. 2, p. 216, pl. 1, figs. 15-20.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 213, pl. 13, fig. 15.

DISTRIBUTION: Barremian? to Albian and Cenomanian?

REMARKS: For description see Singh, 1963, p. 213. A very rare spore.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-151-6 Co-ord: 109.2, 57

FAMILY LAYTONIACEAE

Genus Vitreisporites (Leschik, 1955) Jansonius, 1962

DIAGNOSIS: Bisaccate; central body oval in polar view; longer than broad; bladders finely reticulate and proximally attached at equator; distally reaching almost to distal pole, leaving only a straight narrow germinal area; overall size usually less than 35 microns; bladders large in relation to central body.

Vitreisporites pallidus (Reissinger) Nilsson, 1958

Plate 10, figure 1

1938 Pityosporites pallidus Reissinger, Palaeontographica B, 84, p. 14.
For synonymy 1950, 1955, 1958 and 1958 see Singh, 1963, p. 215.
Pocock, 1962, Palaeontographica B, 111, p. 58-59, pl. 9, figs. 134-135
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 215-216, pl. 14, fig. 1.
Brenner, 1963, The spores and pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, p. 74, pl. 25, figs. 1-2.

DISTRIBUTION: Jurassic and Cretaceous

REMARKS: For description see Singh, 1963, pp. 215-216.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-74-3 Co-ord: 121.1, 52.3

CYCADALES and/or BENNETTITALES

Genus Cycadopites (Wodehouse, 1933) ex. Eilson and Webster, 1946

DIAGNOSIS: Monosulcate pollen grains of more or less spindle-form shape; sulcus extending the total length of grain and broadening at the longitudinal ends; sulcus usually closed in the middle by furrow edges overlapping in shrinkage.

Cycadopites carpentieri (Delcourt and Sprumont) Singh, 1963

Plate 10, figure 2

1955 Monosulcites carpentieri Delcourt and Sprumont, Mem. Soc. Belg. Geol. n.s. 4(5), p. 54, fig. 14.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 218, pl. 14, fig. 3.

DISTRIBUTION: Middle Jurassic to Lower Cretaceous.

REMARKS: For description see Singh, 1963, p. 218. A rare spore.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-151-3 Co-ord: 125.1, 60.9

Cycadopites formosus Singh, 1963

Plate 10, figure 3

1963 Cycadopites formosus Singh, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, University of Alberta, Edmonton, p. 219 (in press).

DISTRIBUTION: Barremian? to Middle Albian

REMARKS: For description see Singh, 1963, p. 219.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-219-7 Co-ord: 127.5, 56.5

Cycadopites sp.

Plate 10, figure 4

REMARKS: For description see Singh, 1963, p. 220. The specimens assigned to this group appear to be identical to those recorded by Singh from Central Alberta. No formal description is given for these spores as only a few specimens were found.

SIZE RANGE: Length 97-104 microns
Breadth 54-57 microns

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-250-3 Co-ord: 118.9, 35.2

Genus Bennettiteaepollenites (Thiergart, 1949) Potonie, 1958

DIAGNOSIS: Outline oval; width about 2/3 the length of the grain; exine smooth; exine has three folds along the long axis which do not reach the margin, of these two folds are close to one another while the third one is on the opposite side.

Bennettiteaepollenites minimus Singh, 1963

Plate 10, figure 5

1963 Bennettiteaepollenites minimus Singh, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta; Unpub. Ph.D. thesis, University of Alberta, Edmonton, p. 221 (in press).

DISTRIBUTION: Barremian? to Middle Albian.

REMARKS: For description see Singh, 1963, p. 221. A rare species.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-219-8 Co-ord: 118.3, 25

CONIFERALES

Genus Alisporites (Daugherty, 1951) restr. Potonie and Kremp, 1956

DIAGNOSIS: Bisaccate pollen without trilete mark; equatorial outline including sacci circular to oval; on the distal side there is a furrow with parallel sides which is not covered by the bladders; the length of the central body is the same as that of the bladders; central body not clearly defined; the sacci are thin, reticulate and very slightly distally pendant.

Alisporites cf. A. microsaccus (Couper) Pocock, 1962

Plate 10, figure 6

1958 Pteruchipollenites microsaccus Couper, Palaeontographica B, 103, p. 151, pl. 26, fig. 13.
For synonymy 1962 see Singh, 1963, p. 224.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 224, pl. 14, fig. 10.

DISTRIBUTION: Upper Jurassic and Lower Cretaceous.

REMARKS: For description see Singh, 1963, p. 224. The specimens found appear to fit Pocock's and Singh's descriptions very well and they are well within the size ranges given. A common species.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-214-5 Co-ord: 123, 30.8

Alisporites thomasii (Couper) Pocock, 1962

Plate 10, figure 7

1958 Pteruchipollenites thomasii Couper, Palaeontographica B, 103, p. 150, pl. 26, figs. 10-12.
For synonymy 1959 and 1962 see Singh, 1963, p. 226.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 226, pl. 14, figs. 11-12.

DISTRIBUTION: Upper Jurassic and Lower Cretaceous.

REMARKS: For description see Singh, 1963, p. 266. This species is identical to that described by Pocock and Singh.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-112-113-1 Co-ord: 116.9, 44.3

Alisporites rotundus Rouse, 1959

Plate 10, figure 8

1959 Alisporites rotundus Rouse, Micropaleontology 5(3), p. 316, pl. 1, fig. 10.
Pocock, 1962, Palaeontographica, B, 111, p. 61-62, pl. 9, figs. 140-141.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 227, pl. 14, figs. 13-14, pl. 15, figs. 1-2.

DISTRIBUTION: Upper Jurassic? and Lower Cretaceous.

REMARKS: For description see Singh, 1963, p. 227. This species is similar to that described by Singh.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-200-8 Co-ord: 121.2, 36.2

Genus Cedripites Wodehouse, 1933

DIAGNOSIS: Bisaccate pollen with thick proximal cap and somewhat curved marginal crest; bladders are fused with proximal cap giving the impression that they are continuous along the proximal pole; bladders are concave on the distal side and partially cover the central body in that region.

Cedripites cretaceus Pocock, 1962

Plate 11, figure 1

1962 Cedripites cretaceus Pocock, Palaeontographica B, 111, p. 63, pl. 9, fig. 145
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 228-229, pl. 15, figs. 3-5.

DISTRIBUTION: Barremian? to Albian

REMARKS: For description see Singh, 1963, p. 229.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-219-8 Co-ord: 118.8, 68.9

Genus Podocarpidites Cookson ex Couper, 1953

DIAGNOSIS: Bisaccate pollen grains; equatorial outline of the central body oval to polyzonal; marginal crest visible; bladders large and distally pendant and cover the distal surface except for a parallel-sided area corresponding to the distal leptoma (furrow); the length of the central body always less than the length of the bladders. This genus includes bisaccate forms with a very distinct central body, marginal crest, and large, slightly pendant bladders.

Podocarpidites ornatus Pocock, 1962

Plate 11, figure 3

1962 Podocarpidites ornatus Pocock, Palaeontographica B, 111, pp. 67-68, pl. 11, figs. 164-166.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 238-239, pl. 15, fig. 14.

DISTRIBUTION: Barremian? to Aptian.

REMARKS: For description see Singh, 1963, pp. 238-239. The ranges of the various measurements taken on these grains agree very closely with those recorded by Pocock, 1962 and Singh, 1963.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-231-7 Co-ord: 119.2, 42

Podocarpidites minisculus Singh, 1963

Plate 11, figure 2

1962 Posocarpidites minisculus Singh, Palynology of the Mannville Group (Lower Cretaceous), Central Alberta, Unpub. Ph.D. thesis, University of Alberta, Edmonton, p. 239 (in press).

DISTRIBUTION: Barremian? to Middle Albian.

REMARKS: For description see Singh, 1963, p. 239. Specimens assigned to this species agree very closely with those recorded by Singh from Central Alberta.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-231- Co-ord: 128.9, 24.1

Podocarpidites canadensis Pocock, 1962

Plate 11, figure 4

1962 Podocarpidites canadensis Pocock, Palaeontographica B, 111, p. 66, pl. 10, figs. 157, 158.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 240-241, pl. 16, figs. 1-3.

DISTRIBUTION: Barremian? to Aptian.

REMARKS: For description see Singh, 1963, p. 241. This species compares closely with P. canadensis Pocock and there is no doubt to its specific identity.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-219-7 Co-ord: 118, 13.2

Genus Pityosporites (Seward, 1914) Manum, 1960

DIAGNOSIS: Bisaccate pollen grains; bladders distally pendant, narrowing towards their roots and diverging; proximally the roots reach the equator of the body or slightly beyond it; distally they are separated by a more or less narrow furrow; bladders reticulate; body wall smooth or very finely sculptured; exine thickness moderate and not conspicuously increasing towards the roots of the bladders.

Pityosporites constrictus Singh, 1963

Plate 11, figure 5

1963 Pityosporites constrictus Singh, Palynology of the Mannville Group (Lower Cretaceous), Central Alberta; Unpub. Ph.D. thesis, University of Alberta, Edmonton, p. 246 (in press).

DISTRIBUTION: Barremian? to Middle Albian.

REMARKS: For description see Singh, 1963, p. 246. The ranges of the various measurement agree very closely with those recorded by Singh from Central Alberta.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-239-7 Co-ord: 118, 69.6

Genus Classopollis (Pflug, 1953) Pocock and Jansonius, 1961

DIAGNOSIS: Distally monoporate pollen, pore not always clearly shown; equatorial outline spherical or oval and lateral view flattened acorn-shaped; exine two-layered; ektexine absent over a circular area around the distal pole and over a triangular area around the proximal pole; endexine at the proximal pole shows a faint trilete scar which has no germinal function; striations always present in a band surrounding the equator, this usually marks a zone of exinal thickening.

Classopollis classoides Pflug ex. Pocock and Jansonius, 1961

Plate 11, figure 9

1953 Classopollis classoides Pflug, Palaeontographica B, 95, p. 91, pl. 16, figs. 29-31, type species.
For synonymy 1961 see Singh, 1963, p. 250.
Pocock, 1962, Palaeontographica, B, 111, p. 71, pl. 11, figs. 171-175
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 250-251, p. 17, fig. 2.

DISTRIBUTION: Jurassic and Cretaceous.

REMARKS: For description see Singh, 1963, p. 251.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-219-8 Co-ord: 120, 49.8

Genus Leioaletes Staplin, 1960

DIAGNOSIS: Spores without germinal sutures but occasionally with a few very fine indistinct grooves parallel to the long axis of the spore; shape ellipsoidal; sculpture minor.

Leioaletes calvatus Singh, 1963

Plate 11, figure 6

1963 Leioaletes calvatus Singh, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, University of Alberta, Edmonton, p. 252, (in press).

DISTRIBUTION: Middle Albian.

REMARKS: For description see Singh, 1963, p. 252. This species appears to be identical to that described by Singh, but the size is somewhat larger. The length given by Singh is about 67 microns and the breadth is about 28 microns, whereas the specimens found in this study are about 97 microns long and 37 microns broad.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-219-7 Co-ord: 125.9, 18.1

Genus Exesipollenites Balme, 1957

DIAGNOSIS: Pollen grains with circular or oval outline; smooth to faintly granulose. Exine is darker in a circular or triangular area at one of the poles. In the centre of this thickening there is a circular area of exinal thinning. The thickened exine gradually becomes lighter and thinner towards the equator.

Exesipollenites tumulus Balme, 1957

Plate figure

1957 Exesipollenites tumulus Balme, C.S.I.R., Australia, Ref. T.C. 25, p. 39, pl. 11, figs. 123-125.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 253, pl. 17, figs. 4, 5.
Brenner, 1963, The spores and pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, p. 87, pl. 35, figs. 2-4.

DISTRIBUTION: Triassic to Upper Cretaceous.

REMARKS: For description see Singh, 1963, p. 253.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-151-6 Co-ord: 116.3, 68.5

Genus Spheripollenites Couper

DIAGNOSIS: Pollen grains, probably monoporate; originally more or less circular but fold readily; exine thin and minutely sculptured; less than 45 microns in diameter.

Spheripollenites scabratus Couper, 1958

Plate 11, figure 8

1958 Spheripollenites scabratus Couper, Palaeontographica 103, B, p. 158, pl. 13, fig. 12.
Pocock, 1962, Palaeontographica B, 111, p. 74, pl. 12, figs. 188-189.

DISTRIBUTION: Jurassic and Lower Cretaceous.

REMARKS: For description see Pocock, 1962, p. 74.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-284-5 Co-ord: 116.1, 47.2

Genus Vittatina (Luber, 1939) Pocock, 1962

DIAGNOSIS: Pollen grains, frequently bisaccate; oval in polar outline; proximal face longitudinally striate, the striations being in the form of ridges; each of approximately the same width; striations may branch and interconnect; bladders or sacci, where present, are small and with or without reticulation; striation continues onto the proximal face of the sacci and appears to be firmly connected with them.

Vittatina cretacea Pocock, 1962

Plate 12, figure 4

1962 Vittatina cretacea Pocock, Palaeontographica B, 111, p. 70, pl. 12, figs. 181-182.

REMARKS: For description see Pocock, 1962, p. 70.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-231-7 Co-ord: 117, 55.6

FAMILY EPHEDRACEAE

Genus Equisetosporites (Daugherty, 1941) Singh, 1963

DIAGNOSIS: Acolpate pollen grains; ellipsoid; sometimes narrower at one end; exine two-layered; smooth endexine overlain by ektexine; ektexinous ridges unbranced, straight, 2 to 12 microns wide in the middle, narrowing at the longitudinal ends, low, gently rounded, running longitudinally, 8 to 12 in number; in a vertical section along the sidth the ridges are semi-circular in outline rather than angular, narrow furrows flank the ridges abruptly, 1 to 3.5 microns wide, unbranched, straight; criss cross

appearance of the ridges is often produced by the twisting of the grains during fossilization and is not a reliable specific character; ridges mostly coalesce just before reaching the longitudinal ends so that the furrows do not reach the margin, unlike some spores of the family Schizaeaceae (eg. Anemia) where ridges and furrows extend to the margin; the ektexine usually markedly thickened at the longitudinal ends.

Equisetosporites cf. E. ovatus (Pierce) Singh, 1963

Plate 12, figure 5

1961 Striainaperturites ovatus Pierce, Minnesota Geol. Surv. Bull. 42, p. 45, pl. 3, fig. 80

1963 Equisetosporites cf. E. ovatus (Pierce) Singh, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 264-265, pl. 17, fig. 16.

DISTRIBUTION: Barremian? to Cenomanian.

REMARKS: For description see Singh, 1963, p. 265. A very rare species.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-151-3 Co-ord: 123, 68.5

Genus Tsugaepollenites Potonie and Venitz, 1934

DIAGNOSIS: Pollen grains; equatorial outline more or less circular, with equatorial velum which may be very narrow, frill-like, radially folded, outer margin irregularly undulating to indented; exine of central body rugulate.

Tsugaepollenites radiostriatus n. sp.

Plate 12, figures 1-3

DESCRIPTION: Grains saccate; equatorial outline circular and equatorial velum is less than 5 microns; exine of proximal surface smooth to slightly scabrate; distal surface thin, smooth to slightly scabrate and depressed at the distal pole, becoming progressively more rugulate towards the equator; rugulae are 2 microns wide and 3 microns high, anastomosing, radially oriented, reaching almost to or slightly overlapping the

equator. The grains often have the appearance of still being inflated. Color is deep red.

SIZE RANGE: Equatorial diameter 54 to 80 microns
Circular area around the distal pole is about 1/3 of the equatorial diameter.
Holotype: equatorial diameter 56.7 microns.
circular area 19 microns.

REMARKS: This species cannot, to the author's knowledge, be assigned with complete certainty to any previously described species, although it appears to be comparable to T. mesozoicus Couper. T. radiostriatus can be distinguished from T. mesozoicus by the presence of anastomosing, radially oriented rugulae on the distal surface. T. radiostriatus resembles the recent species of Tsuga, such as Tsuga canadensis, of the family Pinaceae. In the area of study this species appears to be restricted to the lower part of the section.

REPOSITORY: University of Alberta, Edmonton, Dept of Geology
Palynological Coll.
Slides: Holotype Soc. 27-239-7 Co-ord: 120.6, 35
Paratype Soc. 27-239-8 117.3, 69

MARINE MICROPLANKTON

ORDER DINOFLAGELLATA

FAMILY PERIDINIDAE Kofoid

Genus Paleoperidinium Deflandre, 1934

DIAGNOSIS: Fossil vesicle of general peridinous appearance; plated, but tabulation not well enough preserved to allow more precise generic assignment.

Paleoperidinium cretaceum Pocock, 1962

Plate 13, figure 1

1962 Paleoperidinium cretaceum Pocock, Palaeontographica B, 111, p. 80, pl. 14, figs. 219-221.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 267, pl. 18, fig. 1

DISTRIBUTION: Cretaceous

REMARKS: For description see Singh, 1963, p. 267. In the Fort McMurray area the first appearance of this species represents the marine invasion.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-74-3 Co-ord: 108, 60.9

Paleoperidinium granulatum Singh, 1963

Plate 13, figure 2

1963 Paleoperidinium granulatum Singh, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, University of Alberta, Edmonton, p. 268 (in press).

DISTRIBUTION: Middle Albian.

REMARKS: For description see Singh, 1963, p. 267. The marine invasion is represented by the first appearance of this species.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-112-113-3 Co-ord: 123.8, 24.2

Paleoperidinium nudum Downie, 1957

Plate 13, figure 3

1957 Paleoperidinium nudum Downie, Quart. J. Geol. Soc. 112, p. 424, pl. 20, fig. 11.
Pocock, 1962, Palaeontographica B, 111, pp. 80-81, pl. 14, fig. 225.

DISTRIBUTION: Jurassic and Cretaceous.

REMARKS: For description see Pocock, 1962, p. 81.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
slide: Soc. 27-111-3 Co-ord: 116.9, 73

FAMILY GONYAULACIDAE

Genus Gonyaulax Diesing 1866

DIAGNOSIS: Dinoflagellates with plated tests; 3 to 6 apical plates; 0-4 anterior intercalcary plates; 6 percingular plates; 6 postcingular plates; 0-1 posterior intercalary plates; 1 antapical plate (tabulation formula: 3-6', 0-4a, 6", 6‴, 0-1p, 1""); sutures separating the plates bear high serrated or spinose flanges; longitudinal furrow extends to the apex.

Gonyaulax cf. G. jurassica Deflandre, 1938

Plate 13, figure 4

1938 Gonyaulax jurassica Deflandre, C.R. Acad. Sci., 206, p. 688, fig. 2.

1963 Gonyaulax cf. G. jurassica Deflandre, in Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 270-271, pl. 18, fig. 4.

DISTRIBUTION: Oxfordian to Middle Albian?

REMARKS: For description see Singh, 1963, pp. 270-271. In this study only one specimen was found near the base of the Shale Member of the Clearwater Formation.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-74-3 Co-ord: 121.1, 52.9

ORDER HYSTRICHOSPHAERIDEA Eisenack, 1938

FAMILY HYSTRICHOSPHAERIDAE (Wetzel, 1933) emend. Deflandre, 1937

Genus Hystrichosphaeridium Deflandre, 1937 restr. Eisenack, 1958

DIAGNOSIS: Hystrichosphaeridae with spherical to oval non-plated central vesicle bearing numerous well disposed, generally similar, often funnel-shaped processes, widening and opening towards the outer end.

Hystrichosphaeridium tubiferum (Ehrenberg) Deflandre, 1937

Plate 14, figure 1

1838 Xanthidium tubiferum Ehrenberg, Abh. Wiss. Zn. Berlin Pt. 1, fig. 19.
For synonymy 1933, 1937 and 1958 see Singh, 1963, p. 272.
Pocock, 1962, Palaeontographica, B, 111, p. 82, pl. 15, fig. 230.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, p. 272, pl. 18, fig. 5.

DISTRIBUTION: Barremian to Senonian.

REMARKS: For description see Singh, 1963, p. 272. In this study the first appearance of this species represents the marine invasion.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-74-1 Co-ord: 129.2, 50.3

Hystrichosphaeridium albertense Pocock, 1962

Plate 14, figures 2-3

1962 Hystrichosphaeridium albertense Pocock, Palaeontographica B, 111, 1-3, p. 71, pl. 15, figs. 226-227.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 273-274, pl. 18, figs. 6-7.

DISTRIBUTION: Barremian? to Middle Albian.

REMARKS: For description see Singh, 1963, p. 274. In this section the first appearance of this species marks the beginning of the marine invasion.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slides: Soc. 27-112-113-1 Co-ord: 107.9, 67
Soc. 27-74-1 128.1, 33.2

INCERTAE SEDIS

Genus Odontochitina Deflandre, 1935

DIAGNOSIS: Dinoflagellate cyst with chitinous wall; body globular, with one long apical and two antapical horns; an apical archeopyle is marked by a line of weakness below the apex which divides the body into two unequal parts; an inner wall can be

distinctly seen at the horn bases within the outer one, indicating that it is a cyst within a cyst; the absence of any trace of a girdle or tabulation, and the entirely smooth wall suggests that it is a cyst, rather than the theca of a motile stage.

Odontochitina operculata (Wetzel) Deflandre, 1955

Plate 13, figure 5

1933 Ceratium (Euceratium) operculatum Wetzel, Palaeontographica A, 77, p. 170, pl. 2, figs. 21, 22.
For synonymy 1935, 1955 and 1962 see Singh, 1963, p. 288.
Singh, 1963, Palynology of the Mannville Group (Lower Cretaceous) Central Alberta, Unpub. Ph.D. thesis, pp. 288-289, pl. 20, fig. 9.

DISTRIBUTION: Hauterivian to Upper Cretaceous.

REMARKS: For description see Singh, 1963, pp. 288-289. The first appearance of this species marks the marine invasion in the area of this study.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-74-2 Co-ord: 129, 32.5

Marine cysts (Saccules)

DESCRIPTION: Cysts; ovoid to circular to sub-circular; thin walled, transparent to translucent, frequently folded; unornamented; wall of cyst usually has a faint yellow color; cysts frequently contain rounded crystalline bodies.

SIZE RANGE: Length 25 to 50 microns.
Breadth 20 to 50 microns.

REMARKS: These cysts appear to be identical to those described by Pocock, 1962, but it does not appear to correspond in range of measurements with the forms (Form 1 and Form 2) described by Pocock. Because of the overlap of size ranges between Pocock's two forms, it is felt by the author that in the area of study such a subdivision is not warranted. Marine cysts appear at 117 foot level.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.

ANGIOSPERMAE-INCERTAE SEDIS

Genus Tricolpopollenites Thomson and Pflug, 1953

DIAGNOSIS: For description see Thomson, P.W., and Pflug, H. (1953): Pollen und sporen des mitteleuropaischen Tertiars; Palaeontographica, Abt. B 94, p. 95.

Tricolpopollenites micromunus Groot and Penny, 1960

Plate 9, figures 9-11

1960 Tricolpopollenites micromunus Groot and Penny, Micropaleontology, vol. 6, no. 2, p. 232, pl. 2, figs. 6,7.

1963 Tricolpopollenites micromunus Groot and Penny, in Brenner, 1963, The spores and pollen of the Potomac Group of Maryland, Dept. of Geology, Mines and Water Resources, Bull. 27, p. 93, pl. 39, fig. 7, pl. 40, fig. 1.

REMARKS: For description see Groot and Penny, 1960, p. 232 and Brenner, 1963, p. 93. This species represents the first undoubted angiosperms. In the section studied only one specimen was found in the McMurray Formation Member #2 at 151 feet level. The small size of the grains may be responsible for some specimens being missed in examination of samples. Tricolpopollenites micromunus was first recorded by Groot and Penny from the Arundel and Patapsco Formations of Maryland and Delaware and by Brenner from Maryland, from the upper part of the Patapsco Formation.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: 151-6 Co-ord: 109, 45.

MEGASPORE

Dictyothylakos sp.

1954 Dictyothylakos pesslerae Horst, Z. Geologie 3, pp. 610-613.

1959 Dictyothylakos sp. in Dijkstra, 1959, p. 16.

1963 Dictyothylakos sp. in Singh, 1963, pp. 323-324.

DISTRIBUTION: Neocomian to Middle Albian.

REMARKS: For description see Singh, 1963, pp. 323-324. Dictyothylakos sp. is a mesh-like perispore, which covers the megaspore Thyalakosporites retiarius (Hughes, 1955), Potonie, 1956. The mesh sizes are variable.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-276-12 Co-ord: 117, 56

THALLOPHYTA

Fungi

cf. Brachisporium sp.

Plate 9, figure 8

DESCRIPTION: Multicellular grain, with 3 or more cross walls, which are two lobed, each lobe being triangular in view. Pore is at the base of the grain. The apical cross-wall is 7-8 microns thick, while the other do not exceed 5 microns. The surface of the spore is smooth to slightly rough. Color; dark brown.

REMARKS: The specimens assigned to Brachisporium resemble Brachisporium sp. of Wilson and Webster, 1946. However the latter is somewhat bulkier.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-276-8 Co-ord: 125.5, 57.9

Polyad grains

Plate 12, figures 6,7

DESCRIPTION: Porate grain; equatorial outline elliptical and somewhat widened at the porate end; the grain contains 12 cells, 3 of which are located in the centre of the grain and 9 are arranged around the periphery; the cells are double walled and irregularly shaped. Color bright red, exine smooth to finely granulate.

SIZE RANGE: Length: 105-125 microns
Maximum width: 90-110 microns

REMARKS: Polyad grains occur in Acacieae, Adenanthera, Gagnebina, Ingeae, Pavkia, Piptadenia, and Tetraplensa. In the section studied polyad grains are stratigraphically restricted and are used as index fossils in Subzone A.

REPOSITORY: University of Alberta, Edmonton, Dept. of Geology
Palynological Coll.
Slide: Soc. 27-239-6 Co-ord: 124.2, 38

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SOCONY-VACUUM EXPLORATION COMPANY

Tarsands Exploration Program 1953

Hole No. 27 Location: 2785' South of the North boundary and 2504' west of the East boundary of Section 27-91-10-W4

Elevation: 1061' Total Depth: 296'
Date Spudded: September 20/53 Completed: September 24, 1963

Depth From	Depth To	Condensed Field Log	Footage Recovered
0	73'	Overburden, mainly clay with a little sand and few boulders near the surface.	
73'	81'	Core No. 1: Cut 81 73'-73'2" - sandstone, hard very fine grained, calcareous 73'2"-81' - clay, dark grey, with 1/8" shaly partings, trace of silt in streaks Sample: at 73'	10
81'	88'	Core No. 2: Cut 7' 81'-88' - clay, as above Sample: at 81', a non-oil sand sample Samples of non-oil sand at 10 foot intervals (assuming 50 feet on non-oil sand material). Samples of oil sand at 3 foot intervals, starting with the sixth 4" segment (assuming 120 feet of oil sand)	7'
88'	98'	Core No. 3: Cut 10' 88-88'4" - clay, as above 88'4"-88'7" - sandstone, hard, very fine grained, silty, calcareous 88'7"-91'8" - clay, dark grey, shaly, partings, trace silt in streaks 91'8"-92'6" - clay, dark grey, with green sand, very fine grained, in streaks and spots replacing the silty streaks of the core above. Sand increases downward to compose 75% of the core 92'6"-97'7" - sandstone, green, very glauconitic, silty with a trace of clay, partly calcareous. Smells of oil, assumed to be first oil sand 97'7"-98' - sandstone, hard, very fine grained, silty, calcareous Sample: at 91' Sample: T-94'2"; C-94'6"; B-94'10"	10'
98'	101'10"	Core No. 4: Cut 3'10" 98-99' - sandstone, green, very fine grained, silty, calcareous	3'3"

Depth From	To	Condensed Field Log	Footage Recovered
		99'-101'3" - sandstone, green, very fine grained, silty, partly calcareous, with few dark grey clay beds, smells of oil. Sample: T-none; C-99'; B-99'4"	
101'10"	112'	Core No. 5 - Cut 10'2" 101'10"-107'6" - clay with few small streaks of sand and silt. 107'6"-111'4" - oil sand, low grade, finely inter-bedded with clay, 90% oil sand. Sample: T-108'; C-108'4"; B-108'8"	9'6"
112'	122'	Core No. 6 - Cut 10' 112'-114'6" - oil sand, low grade with clay, 75% oil sand 114'6"-116'4" - oil sand, fine grained, silty, low grade 116'4"-116'10" - clay with 1/8" bed of oil sand 116'10"-117' - oil sand, silty, low grade, with clay 117'1"-117'6" - sandstone, very fine grained, hard, cal-careous, with trace of oil, carbonized fossils 117'6"-120'3" - clay, calcareous with few streaks of oil sand, very fine grained, silty, brown, very low grade 120'3"-121'6" - oil sand, very fine grained, silty, low grade Sample: T-114'; C-114'4"; B-114'8" T-117'; C-117'4"; B-117'8" T-121'; C-121'4"; B-121'8"	9'6"
122'	132'	Core No. 7: Cut 10' 122-132' - oil sand, brown, very fine grained, silty, trace clay, low grade; Sample: T-124'; C-124'4"; B-124'8" T-127'; C-127'4"; B-127'8" T-130'; C-130'4"; B-130'8"	10'
132'	142'	Core No. 8: Cut 10' 132'-132'2" - oil sand, as above 132'2"-132'4" - clay, grey, silty 132'4"-139'6" - oil sand with clay streaks to 2" thick, 75% oil sand, low grade; Sample: T-133'; C-133'4"; B-133'8" T-136'; C-136'4"; B-136'8"	7'6"
142'	152'	Core No. 9: Cut 10' 142'-148'2" - oil sand with thin clay streaks, 10% clay 148'2"-148'8" - oil sand, hard, slightly calcareous, trace silt, low grade; 148'8"-151'8" - oil sand, very fine grained, low grade, with few clay streaks, 10% clay. Sample No. 27-15: T-142'; C-142'4"; B-142'8" T-145'; C-145'4"; B-145'8" T-148'; C-148'4"; B-148'8" T-151'; C-141'4!, B-151'8"	9'8"

Depth From	To	Condensed Field Log	Footage Recovered
152'	162'	Core No. 10: Cut 10' 152'-153'2" - sandstone, hard, calcareous, very fine grained, with trace oil 153'2"-160'9" - oil sand, silt to fine grained, poorly sorted, with clay streaks, 20% clay; Sample: T-153'; C-153'4"; B-153'8" T-156'; C-156'4"; B-156'8" T -159'; C-159'4; B-159'8"	8'9"
162'	172'	Core No. 11; Cut 10' 162'-167'3" - oil sand, brown, very fine grained, trace clay, very low grade; 167'3"-169'6" - clay interbedded with oil sand, very fine grained, low grade; Sample: T-162'; C-162'4"; B-162'8" T-165'; C-165'4"; B-165'8" T-168'; C-168'4"; B-168'8"	7'6"
172'	182'	Core No. 12; But 10' 172'-172'4" - clay with 1/16" streaks of oil sand, brown, very fine grained, low grade; 172'4"-173'1" - sandstone, hard, very fine grained, calcareous with oil in fractures; 173'1"-181'2" - clay with 1/4" thick streaks of oil sand spaced up to 1" apart; 1/2" thick sandstone beds, hard, very fine grained, calcareous at 177'2", 180'3"	9'2"
182'	192'	Core No. 13 : Cut 10' 182'-182'1" - sandstone, hard, v.f.g., calc. 182'1"-184'7" - clay with oil sand streaks, 75% clay; 184'7"-184'8" - sandstone, as above 184'8"-186'1" - clay, with oil sand streaks, as above; 186'1"-186'2" - sandstone, as above; 186'2"-189' - clay with oil sand streaks as above 189'-180'1" - sandstone, as above 189'1"-191'1" - clay with oil sand streaks, as above; 191'1"-191'2" - sandstone; as above 191'2"-191'5" - clay with oil sand streaks Sample: T-183'; C-183'4"; B-183'8" T-186'; C-186'4"; B-186'8" T-189'; C-189'4"; B-189	9'5"
192'	202'	Core No. 14: Cut 10' 192-192'1" - sandstone, very fine grained, hard, calcareous; 192'1"-196'10" - clay, silt and oil sand, very fine grained, finely interbedded; 196'10"-197' - sandstone, as above 197'-201'4" - clay, silt, oil sand, and sandstone, calcareous, finely interbedded;	9'4"

Depth From	To	Condensed Field Log	Footage Recovered
		Sample: T-192'; C-192'4"; B-192'8" T-195'; C-195'4"; B-195'8" T-198'; C-198'4"; B-198'8"	
202'	212'	Core No. 15: Cut 10' 202'-203' - clay with few oil sand streaks, low grade; 203'-203'2" - sandstone, hard, very fine grained, calcareous; 203'2"-204'3" - clay with oil sand streaks, as above; 204'3"-204'4" - sandstone, as above; 204'4"-205' - clay with oil sand, as above 204'-205'1" - sandstone, as above 205'1"-207' - clay with oil sand, as above 207'-207'1" - sandstone, as above 207'1"-207'3" - clay with oil sand, as above 207'3"-208'1" - sandstone, as above, with trace oil in partings 208'1"-208'6" - clay with oil sand streaks, low grade 208'6"-208'7" - sandstone, hard, very fine grained, calcareous; 208'7"-209'3" - clay with oil sand, as above' 209'3"-209'4" - sandstone, as above 209'4"-210'6" - clay with oil sand, as above; 210'6"-210'7" - sandstone, as above; 210'7"-211'2 " - clay with oil sand; Sample: T-204'; C-204'4"; B-204'8" Sample: T-none; C-207'4"; B-none Sample: T-none; C-210'4"; B-none	9'2"
212'	222'	Core No. 16: Cut 10' 212'-212'7" - clay with thin streaks of oil sand, very fine grained, silty, low grade; 212'7"-212'8" - sandstone, hard, very fine grained, hard; 212'8"-214'9" - clay with oil sand streaks as above; 214'9"-214'11" - sandstone, as above; 214'11"-217'9" - clay with oil sand streaks, as above; 217'9"-217'11" - oil sand, soft, fine grained, good grade; 217'11"-218'7" - clay with oil sand streaks, v.f.g. low grade; 218'7"-218'11" - oil sand, fine grained, hard, calcareous; 218'11"-219'6" - clay with oil sand streaks, v.f.g., low grade; 219'6"-219'8 " - oil sand, fine grained, good grade; 219'8"-219'11" - clay with oil sand streaks, v.f.g. low grade; 219'11"-220' - oil sand, hard, fine grained, calcareous; 220'-221'9" - oil sand, hard, fine grained, calcareous Sample: T-213'; C-213'4"; B-213'8" Sample: T-216'; C-216'4"; B-216'8" Sample: T-219'; C-219'4"; B-219'8"	8'9"

Depth From	Depth To	Condensed Field Log	Footage Recovered
222'	232'	Core No. 17: Cut 10' 222'-222'4" - clay with thin oil sand streaks, v.f.g. low grade; 222'4"-222'5" - oil sand, fine grained, good grade; 222'5"-222'8" - sandstone, hard, very fine grained, calcareous, trace oil; 222'8" - 222'11" - clay with thin streaks oil sand, brown, v.f.g., low grade. 222'11" - 223' - sandstone, hard, very fine grained, calcareous, trace oil; 223'-223'4" - clay with oil sand streaks, v.f.g., low grade; 223'4"-223'6" - oil sand, fine grained, good grade; 223'6"-224'4" - clay with oil sand streaks, v.f.g., low grade; 224'4"-224'8" - oil sand, fine grained, good grade; 224'8"-225'8" - clay with beds of oil sand, fine grained, good grade; 225'8"-225'10" - sandstone, hard, fine grained, calcareous with oil; 225'10"-226'9" - clay with beds of oil sand to 1/2" thick, fine grained, good grade; 226'9"-226'10" - sandstone, v.f.g., hard, calc. 226'10" - 227'8" - clay with streaks oil sand, brown, v.f.g., silty, low grade; 227'8"-227'9" - sandstone, as above 227'9"-229'3" - clay with oil sand streaks, v.f.g., low grade; 229'3"-229'4" - sandstone, as above 229'4"-230'11" - clay with oil sand streaks, brown, v.f.g., low grade; 230'11"-231' - sandstone, as above; Sample: T-222'; C-222'4"; B-222'8" Sample: T-225; C-225'4"; B-225'8" Sample: T-228'; C-228'4"; B-228'8"	9'
232'	242'	Core No. 18: Cut 10' 232'-232'1" - sandstone, hard, v.f.g., calc. 232'1"-234'6" - clay with oil sand streaks, v.f.g., brown, low grade; 234'6"-234'7" - sandstone, as above; 234'7"-238'3" - clay with oil sand streaks, as above; 238'3"-238'7" - sandstone, hard, fine grained, calc., with oil; 238'7"-239'5" - clay with streaks of oil sand, v.f.g., low grade, and thin beds of oil sand, fine grained, good grade; Sample: T-233'; C-233'4"; B-233'8" Sample: T-236'; C-236'4"; B-236'8"	7'5"

Depth From	Depth To	Condensed Field Log	Footage Recovered
242'	252'	Core No. 19: Cut 10' 242'-244'7" - clay with oil sand streaks, v.f.g., poor grade and fine grained, good grade; 244'7"-244'8" - sandstone, hard, v.f.g., calcareous; 244'8"-246'10" - clay with oil sand, as above; 246'10"-246'11" - sandstone, as above; 246'11"-248'5" - clay with oil sand, as above; 248'5"-248'6" - sandstone, as above; 248'6"-249'10" - clay with oil sand, as above; 249'10"-249'11" - sandstone, as above; 249'11"-250'5" - clay with oil sand, as above; Sample: T-242; C-242'4"; B-242'8" Sample: T-245'; C-245'4"; B-245'8" Sample: T-245; C-246'4"; B-246'8"	8'5"
252'	260'6"	Core No. 20: Cut 8'6" 242'-253'2" - clay with oil sand in streaks, v.f.g., low grade and in beds, fine grained, good grade; 253'2"-253'3" - sandstone, hard, v.f.g., calc. 253'3"-260'6" - clay with oil sand as above. Core stuck in barrel and all broken; Sample: T-253; C-253'4"; B-253'8" Sample: T-256; C-256'4"; B-256'8"	8'6"
260'6"	262'	Core No. 21: Cut 1'6"	0
262'	271'	Core No. 22: Cut 9' 262'-263'6" - clay with oil sand in streaks, v.f.g., low grade, and beds fine grained, good grade; 263'6"-263'10 - sandstone, hard, v.f.g., calc., with oil 263'10"-266'3" - clay with oil sand, as above; Sample: T-262'; C-262'4"; B-262'8" Sample: T-265'; C-265'4"; B-265'8"	4'3"
271'	276'	Core No. 23: Cut 5'; Recovered 271'-271'5" - oil sand, fine grained, good grade; 271'5"-271'10" - clay with oil sand streaks, as above; 271'10"-272'9" - oil sand, as above; 272'9"-273'3" - clay with oil sand, as above; 273'3"-274'4" - oil sand with trace clay in streaks; 274'4"-275' - clay with oil sand streaks, fine grained, good grade; Sample: T-271'; C-271'4"; B-271'8!	
276'	286'	Core No. 24: Cut 10' 276'-276'3" - sandstone, hard, v.f.g., calcareous; 276'3"-276'6" - clay, silty with trace oil sand; v.f.g. 276'6"-276'10" - oil sand, fine grained, good grade; 276'10"-281'2" - clay, silty, with trace oil sand in streaks; 281'2"-282'11" - oil sand, fine grained, good grade;	7'

Depth From	Depth To	Condensed Field Log	Footage Recovered
		282'11"-283' - clay, light grey, calcareous; Sample: T-277'; C-277'4"; B-277'8" Sample: Last McM. at 282'9"	
286'	296'	Core No. 25: Cut 10' 286'-293'4" - clay, white, limy, part silty; Sample: at 295' Cored: 223' Recovered: 183'3" Recovery: 82%	7'4"

PLATE 1

(All figures x 500)

Figure 1. Sphagnumsporites antiquasporites (Wilson and Webster) Pocock; medium focus on proximal surface. Note the distal polar thickening ..... (p. 33)

Figure 2. Sphagnumsporites psilatus (Ross) Couper; medium focus on proximal surface ..... (p. 34)

Figures 3-4. Lycopodiumsporites austroclavatidites (Cookson) Pocock; 3-distal view; 4-distal view ..... (p. 34)

Figure 5. Lycopodiumsporites cerniidites (Ross) Delcourt and Sprumont; distal view ..... (p. 35)

Figures 6-7. Lycopodiumsporites clavatoides Couper, 1958; 6-proximal 7-distal view ..... (p. 36)

Figure 8. Lycopodiumsporites marginatus Singh, 1963; proximal view... (p. 36)

Figure 9. Lycopodiumsporites sp. A. proximal view ..... (p. 36)

Figure 10. Lycospora cretacea Pocock; distal view ..... (p. 37)

Figure 11. Acanthotriletes varispinosus Pocock; proximal view ..... (p. 39)

Figure 12. Osmundacidites wellmanii Couper; proximal view; note granular papillate structure ..... (p. 40)

Figure 13. Todisporites minor Couper; proximal view ..... (p. 40)

Figure 14. Lycopodiacidites baculatus Pocock; proximal view; note slightly expanded tips of baculae ..... (p. 38)

Figure 15. Reticulatisporites castellatus Pocock ..... (p. 38)

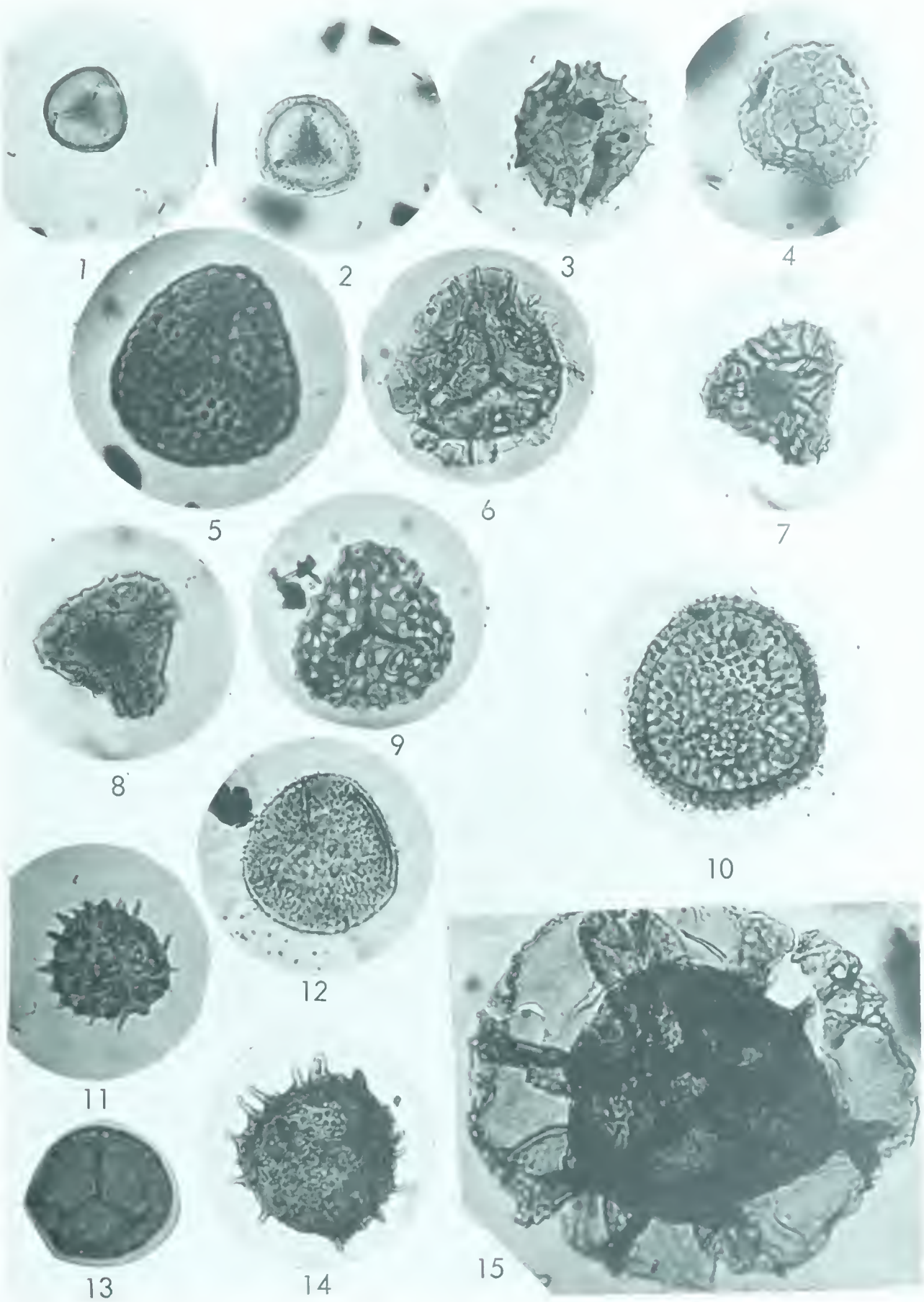
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PLATE 2

(All figures x 500)

Figure 1. Reticulatisporites castellatus Pocock ..... (p. 38)

Figure 2. Appendicisporites tricornitatus Weyland and Greifeld; distal view ..... (p. 41)

Figures 3-4. Appendicisporites erdtmanii Pocock; 3-4 proximal view ..... (p. 42)

Figure 5. Appendicisporites cooksoni (Balme) Pocock; distal view ..... (p.)

Figure 6. Appendicisporites crimensis (Bolkhovitina) Pocock; mid-focus ..... (p. 43)

Figure 7. Appendicisporites sp.; note granular central area

Figures 8-9. Appendicisporites trichacanthus (Maljavkina) var. dissectus (Markova) Singh;
8 - belongs to group A. mid-focus
9 - belongs to group B. proximal view ..... (p. 43)

Figure 10. Appendicisporites unicus (Markova) Singh; mid-focus ..... (p. 44)

Figure 11. Appendicisporites perplexus Singh; mid-focus ..... (p. 45)

Figure 12. Appendicisporites degeneratus Thiergart; mid-focus ..... (p. 45)

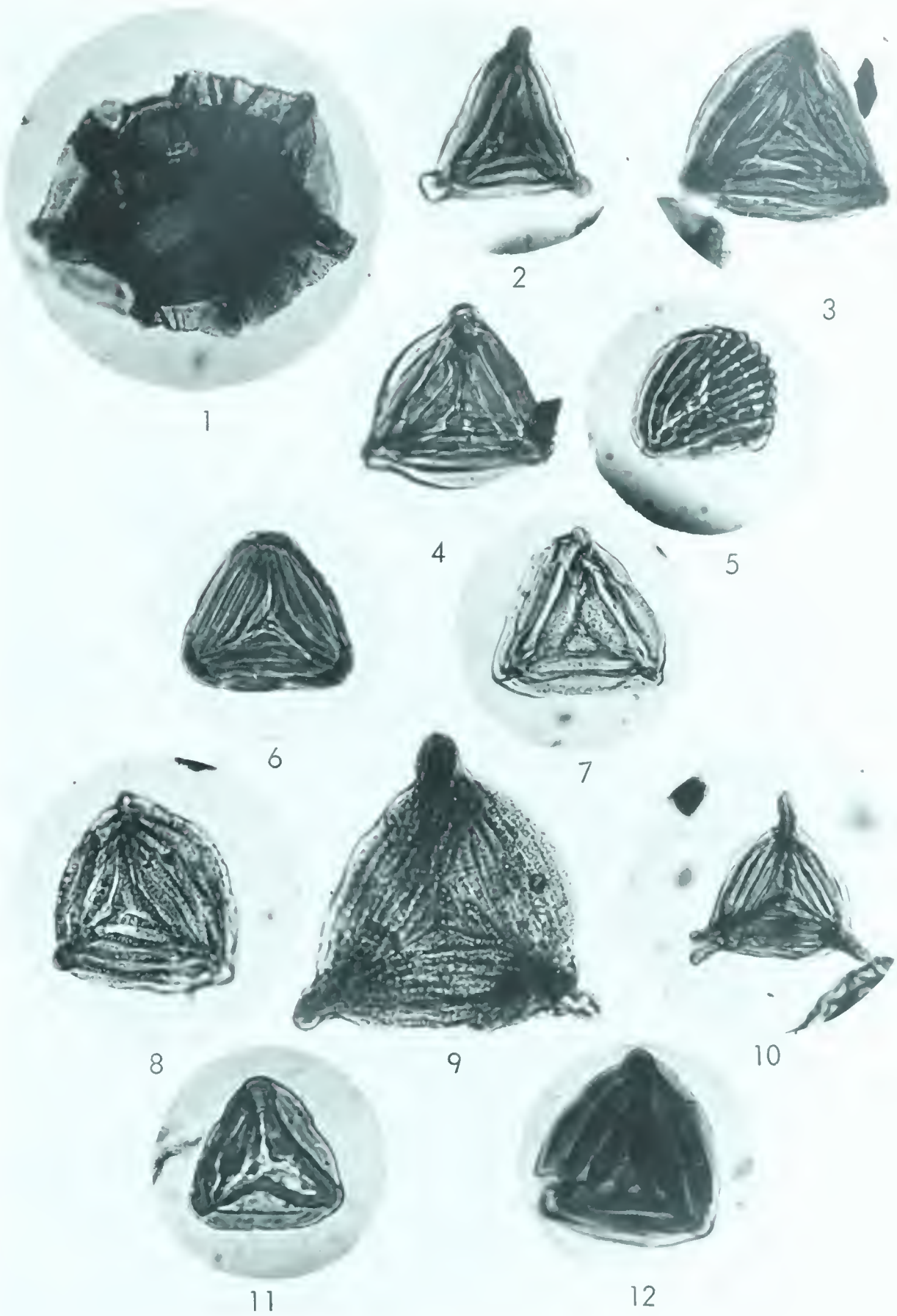
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PLATE 3

(All figures x 500)

Figure 1. Cicatricosisporites dorogensis Potonie and Gelletich; distal view ..... (p. 46)

Figure 2. Cicatricosisporites dorsostriatus (Bolkhovitina) Singh; distal view, note equatorial girdle and ribs ..... (p. 47)

Figures 3-4. Cicatricosisporites irregularis n. sp.; 3-proximal view (Holotype), 4-proximal view, note irregularly developed sinuous ribs ..... (p. 47)

Figure 5. Cicatricosisporites perforatus (Baranov, Nemkova, Kondratiev) Singh; proximal view, note single row of holes on the proximal ribs ..... (p. 48)

Figure 6. Cicatricosisporites mediostriatus (Bolkhovitina) Pocock; proximal view, note ribs forming a rhombic net ..... (p. 48)

Figure 7. Cicatricosisporites sp. A.; proximal view, note a single row of holes on distal ribs ..... (p. 49)

Figure 8. Cicatricosisporites sp. B.; mid-focus ..... (p. 49)

Figure 9. Chomotriletes almegrensis Pocock; mid focus ..... (p. 50)

Figure 10. Schizaeoisporites eocenicus (Selling) Potonie; equatorial view ..... (p. 50)

Figure 11. Schizaeoisporites phaseolus Delcourt and Sprumont; equatorial view ..... (p. 51)

Figure 12. Dictyotriletes pseudoreticulatus (Couper) Pocock; proximal view ..... (p. 52)

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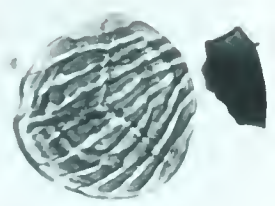

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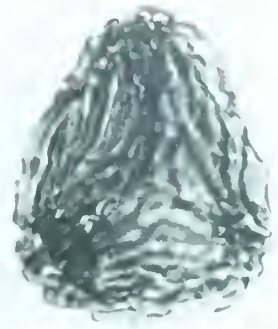

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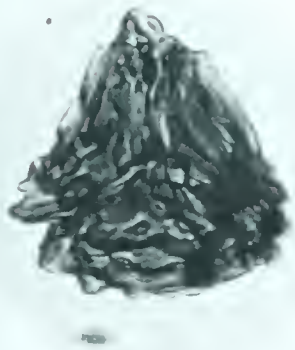

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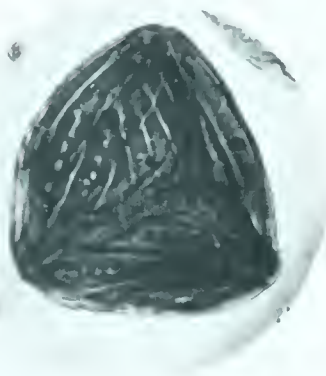

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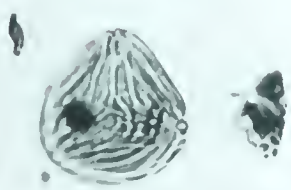

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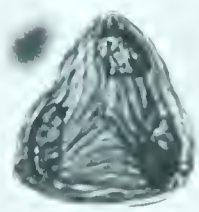

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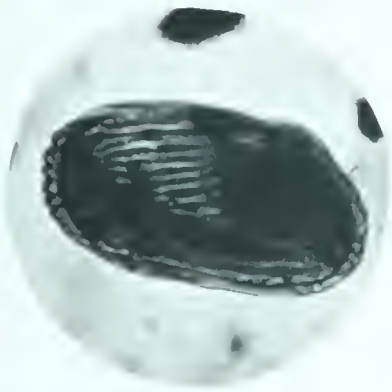

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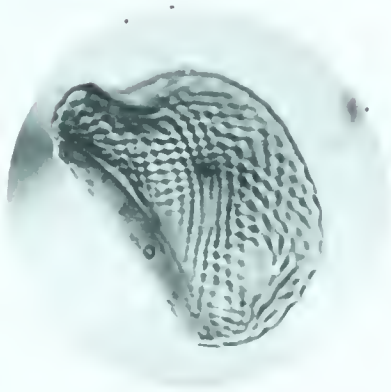

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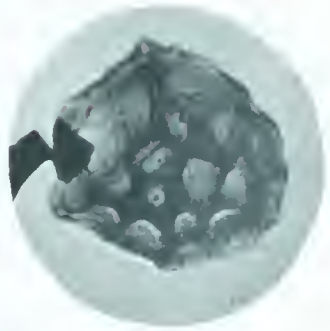

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PLATE 4

(All figures x 500)

Figure 1. Dictyotriletes granulatus Pocock; mid-focus ..... (p. 52)

Figure 2. Dictyotriletes southeyensis Pocock; proximal view ..... (p. 53)

Figure 3. Lygodiumsporites sp.; proximal view, note the densely verrucate exine ..... (p. 53)

Figures 4,5,6. Lygodiumsporites ambiperforatus n. sp.
4 - Holotype proximal view
5-6 - Paratypes proximal view
note small elongated perforations near equatorial outline .. (p. 54)

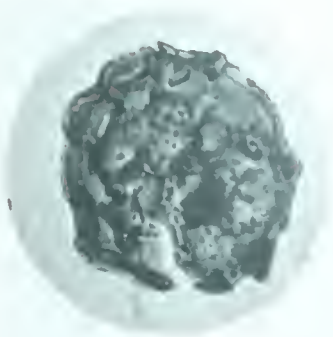
Figure 7. Gleicheniidites circinidites (Cookson) Brenner; proximal view; note that equatorial thickening extends around the apices ..... (p. 55)

Figure 8. Gleicheniidites senonicus Ross; proximal view ..... (p. 55)

Figure 9. Cyathidites minor Couper; proximal view ..... (p. 56)

Figure 10. Cyathidites australis Couper; proximal view ..... (p. 56)

Figure 11. Trilobosporites hannonicus (Delcourt and Sprumont) Potonie; mid-focus, note the thickened ektexine on the rounded apices in the form of a cap ..... (p. 57)



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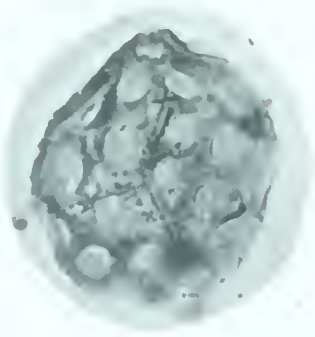

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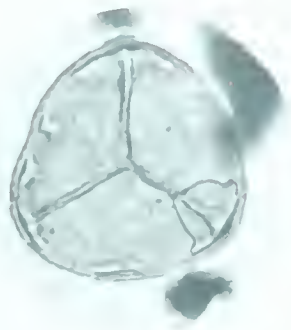

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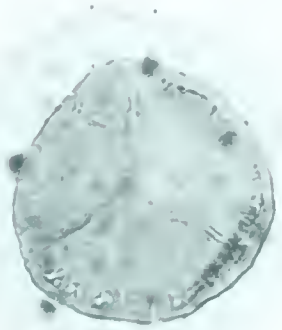

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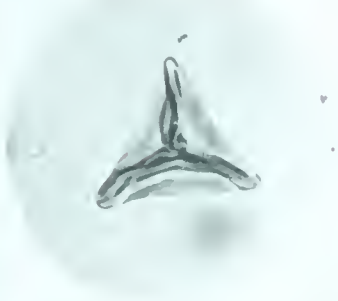

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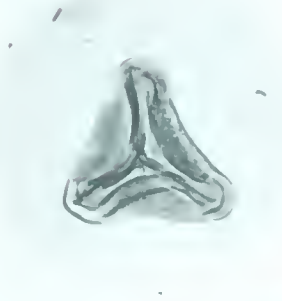

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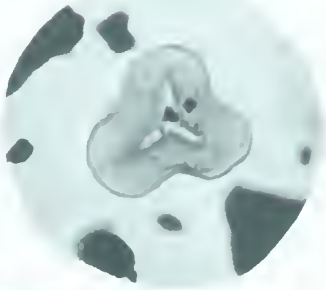

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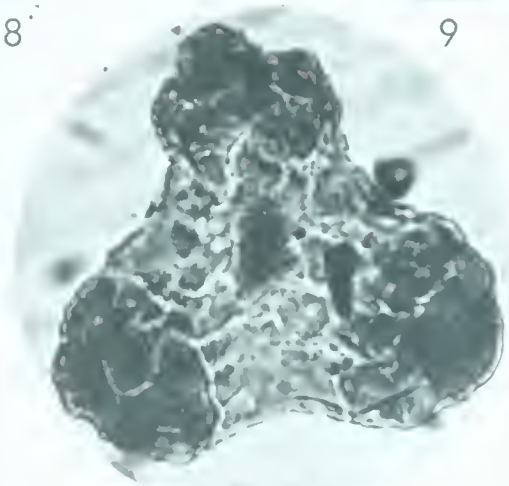

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PLATE 5

(All figures x 500)

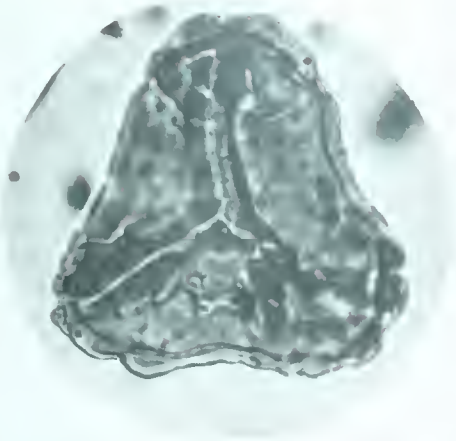
Figure 1. Trilobosporites hannonicus (Delcourt and Sprumont) Potonie; proximal view, note the thickened ektexine on the rounded apices in the form of a cap ..... (p. 57)

Figures 2-3. Trilobosporites apiverrucatus Couper;
2 - proximal view, note pronounced apical ornamentation
3 - proximal view, note larger verrucae bordering the margo ..... (p. 58)

Figure 4. Trilobosporites trioreticulosus Cookson and Dettmann; proximal view, note shallow reticulum and broad muri and polygonal to rounded lumina at apices ..... (p. 59)

Figures 5-6. Trilobosporites canadensis Pocock;
5 - proximal view, note verrucae bordering the laesurae in a single line
6 - proximal view, note verrucae arise from thick ektexine.. (p. 58)

Figure 7. Trilobosporites sp.; proximal view, note size of verrucae increasing toward periphery ..... (p. 59)



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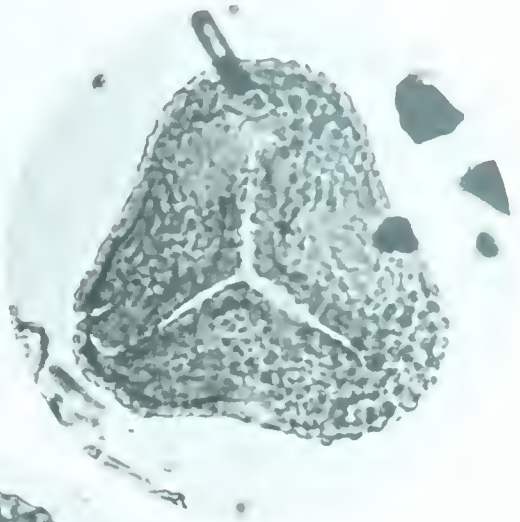

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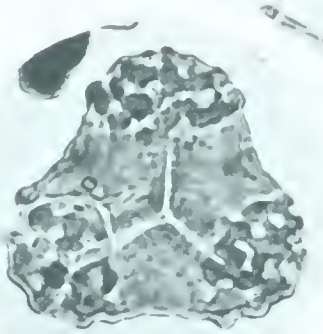

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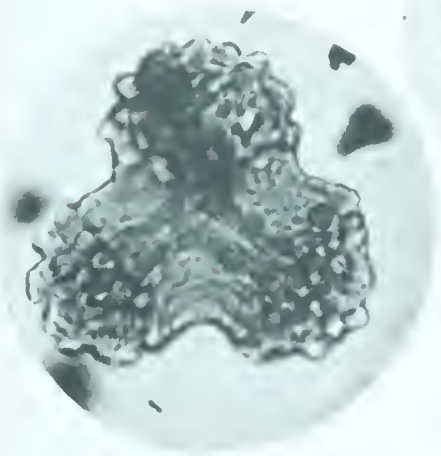

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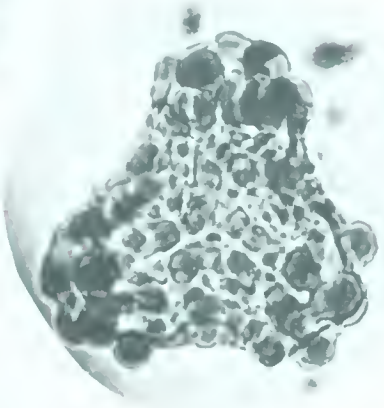

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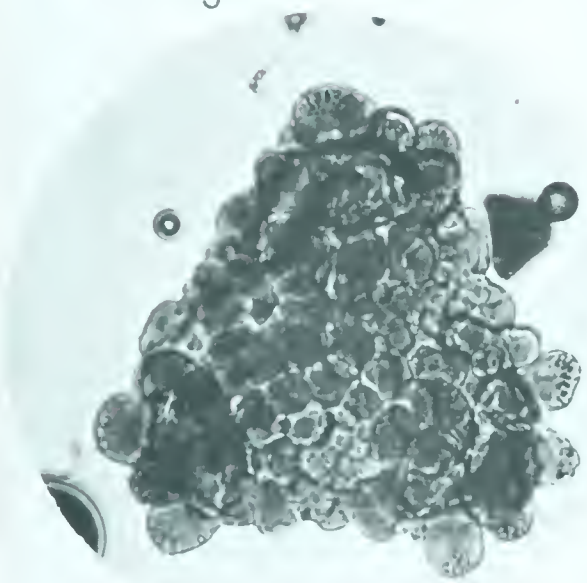

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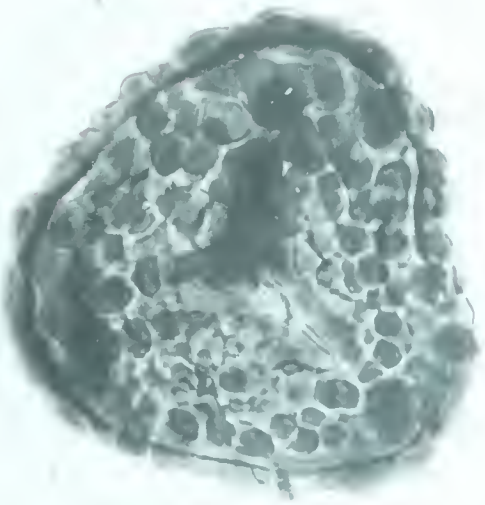

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PLATE 6

(All figures x 500)

Figure 1. Pilosisporites verus Delcourt and Sprumont; proximal view, note spines concentrated in the apical areas ..... (p. 60)

Figures 2-3. Pilosisporites trichopapillosus (Thiergart) Delcourt and Sprumont;
2- mid focus, note echinate ornamentation
3- equatorial view ..... (p. 60)

Figure 4. Concavissimisporites punctatus (Delcourt and Sprumont) Brenner; proximal view; not sub-granulose ornamentation .... (p. 61)

Figure 5. Concavissimisporites parkinii (Pocock) Singh; proximal view, not thick exine ..... (p. 61)

Figure 6. Concavissimisporites variverrucatus (Couper) Brenner; proximal view, note verrucate ornamentation ..... (p. 62)

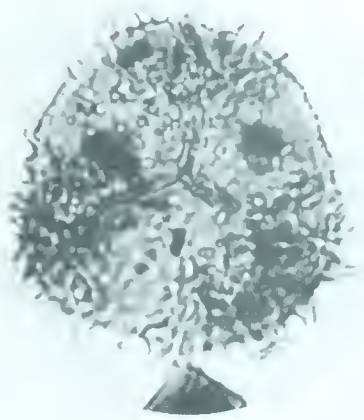
Figures 7-8. Concavissimisporites singhi n. sp.
7 - Holotype, proximal view
8 - Paratype, proximal view, note two layered exine and undulose appearance of the surface ..... (p. 62)

Figure 9. Deltoidospora hallii Miner; proximal view ..... (p. 63)

Figure 10. Deltoidospora junctum (Kara Mursa) Singh; distal view, note distal exine is folded on itself perpendicular to the apices... (p. 64)

Figure 11. Deltoidospora psilostoma Rouse; mid-focus ..... (p. 63)

Figure 12. Hymenozonotriletes mesozoicus Pocock; proximal view, note equatorial zone ..... (p. 64)



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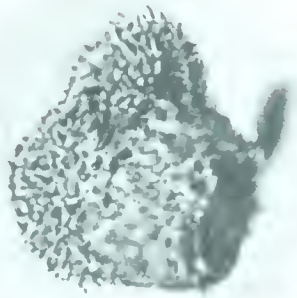

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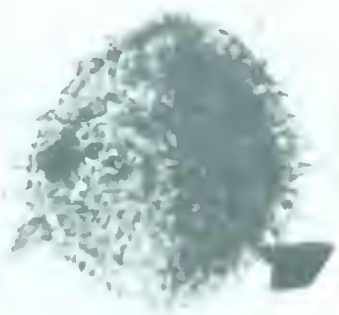

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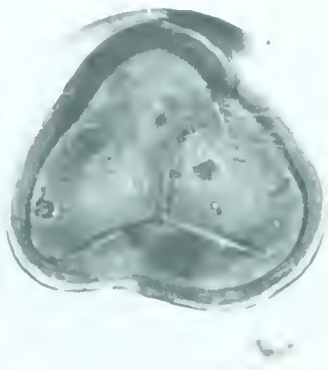

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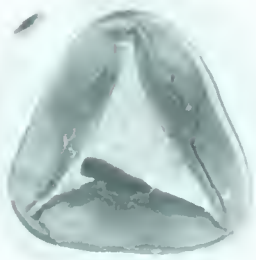

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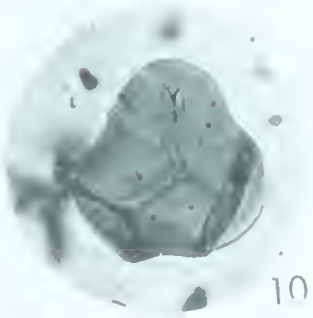

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PLATE 7

(All figures x 500)

Figure 1. Couperisporites complexus (Couper) Pocock; distal view, note polyzonal based hollow bosses in inner area ..... (p. 65)

Figure 2. Staplinisporites caminus (Balme) Pocock; proximal view, note indication for two concentric bands of thickened exine on distal surface ..... (p. 66)

Figure 3. Taurocusporites minor Singh; proximal view ..... (p. 66)

Figure 4. Aequitriradites spinulosus (Cookson and Dettmann) Cookson and Dettmann; proximal view, note membranous, scabrate zona ..... (p. 67)

Figure 5. Aequitriradites variabilis Pocock; distal view, note exinous breakdown about the distal pole ..... (p. 67)

Figure 6. Rouseisporites reticulatus Pocock; distal view, note diagnostic three holes penetrating equatorial flange ..... (p. 68)

Figure 7. Rouseisporites triangularis Pocock; distal view, note faint laesurae terminating at the conical depression at the apices.. (p. 69)

Figures 8-9. Cooksonites variabilis Pocock;
8 - distal view; smaller size range
9 - distal view; larger size range ..... (p. 69)

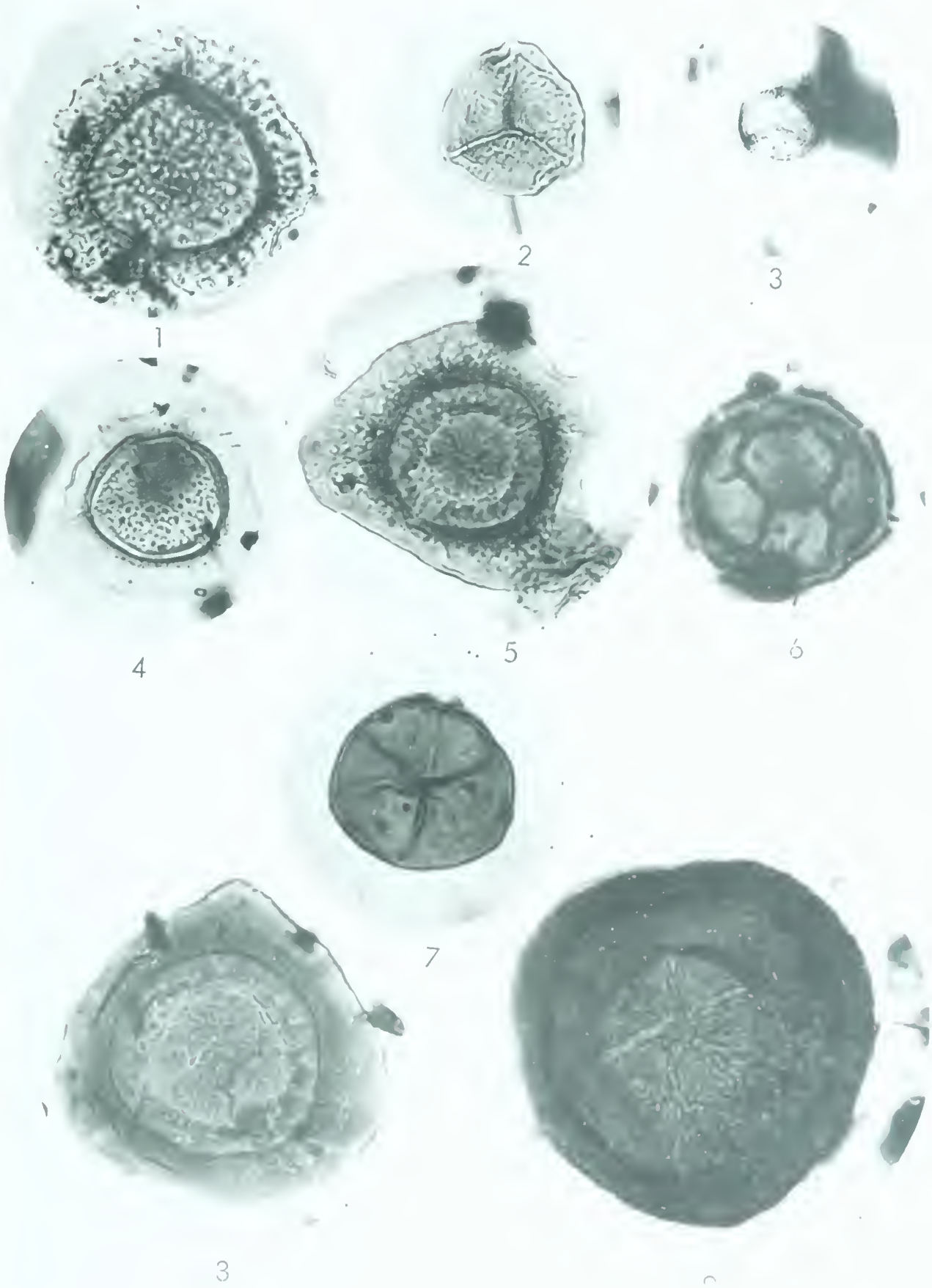
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PLATE 8

(All figures x 500)

Figures 1,2. Cooksonites reticulatus Pocock;
1 - mid focus; same specimen
2 - distal view; same specimen ..... (p. 70)

Figures 3,4. Januasporites spiniferus Singh;
3 - distal view
4 - distal view, note difference in width of zona ..... (p. 71)

Figure 5. Januasporites reticularis Pocock; distal view, note distal exine absent over a circular area ..... (p. 72)

Figures 6,7. Lycopodiacidites cf. L. ambifoveolatus Brenner;
6 - distal view, note smooth proximal surface
7 - distal view ..... (p. 37)

Figure 8. Laevigatosporites ovatus Wilson and Webster; equatorial view, not straight suture ..... (p. 74)

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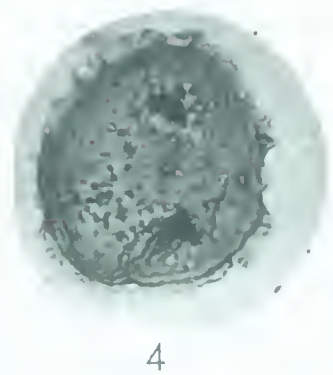

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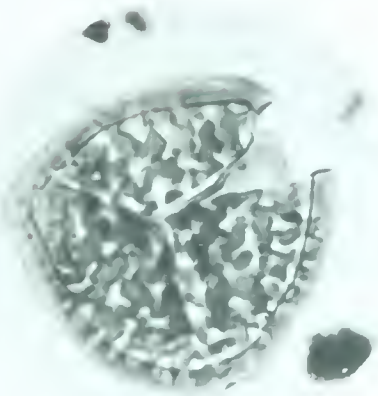

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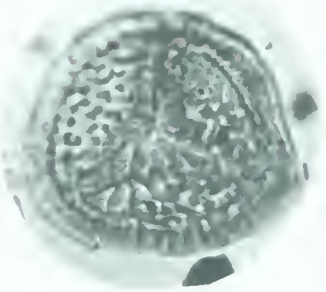

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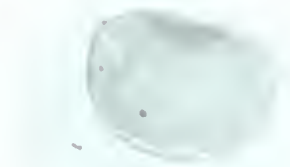

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PLATE 9

(All figures x 500 unles otherwise stated)

Figure 1. Verrucosisporites asymmetricus (Cookson and Dettmann) Pocock; distal view, note irregularly shaped, flat topped verrucae .... (p. 72)

Figure 2. Verrucosisporites rotundus Singh; mid-focus, note flat rounded verrucae ..... (p. 72)

Figure 3. Verrucosisporites sp.; distal view ..... (p. 73)

Figure 4. Microreticulatisporites uniformis Singh; proximal view ..... (p. 73)

Figure 5. Schizosporis reticulatus Cookson and Dettmann; polar view, figure shows partial separation into two equal parts, x 150.... (p. 74)

Figure 6. Schizosporis cooksoni Pocock; equatorial view..... (p. 75)

Figure 7. Schizosporis parvus Cookson and Dettmann; mid-focus ..... (p. 75)

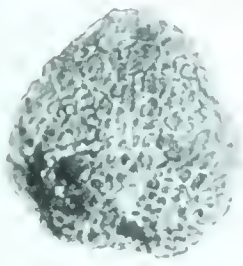
Figure 8. cf. Brachisporium sp. ..... (p.)

Figures 9,10,11. Tricolpopollenites micromunus Groot and Penny; polar view

9 - medium focus, note double layered exine

10 - high focus showing retipilate ornamentation

11 - low focus ..... (p.)



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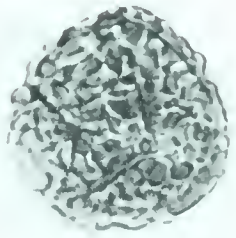

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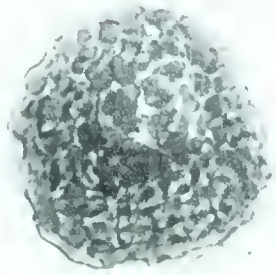

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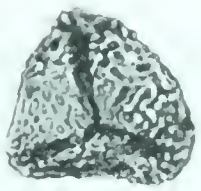

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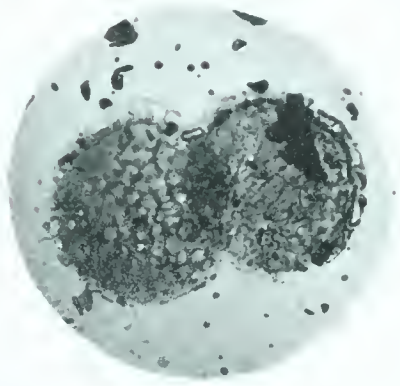

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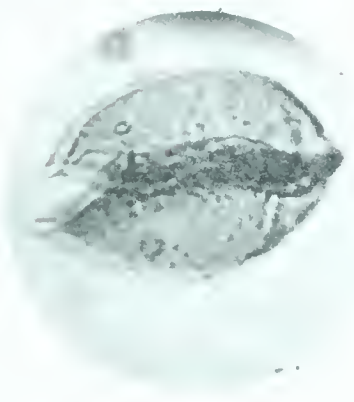

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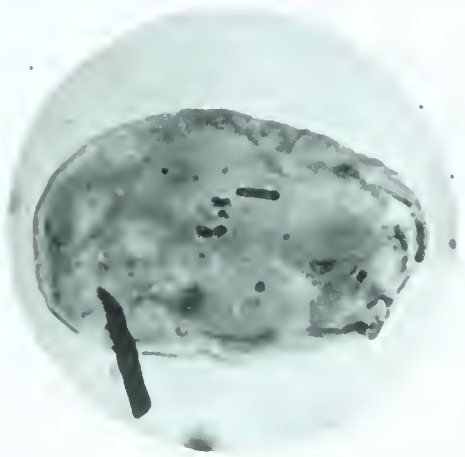

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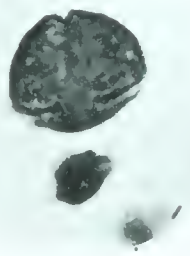

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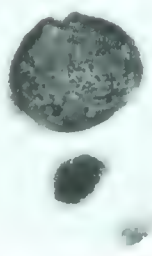

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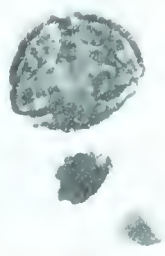

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PLATE 10

(All figures x 500)

Figure 1. Vitreisporites pallidus (Reissinger) Nilsson; distal view ..... (p. 76)

Figure 2. Cycadopites carpentieri (Delcourt and Sprumont) Singh; proximal view ..... (p. 77)

Figure 3. Cycadopites formosus Singh; proximal view ..... (p. 77)

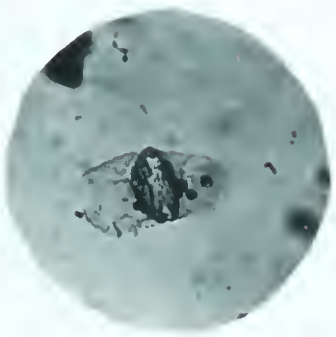
Figure 4. Cycadopites sp.; proximal view, note granulose exine ..... (p. 77)

Figure 5. Bennettiteaepollenites minimus Singh; proximal view ..... (p. 78)

Figure 6. Alisporites cf. A. microsaccus (Couper) Pocock; distal view.. (p. 78)

Figure 7. Alisporites thomassii (Couper) Pocock; distal view .....

Figure 8. Alisporites rotundus Rouse; distal view ..... (p. 79)



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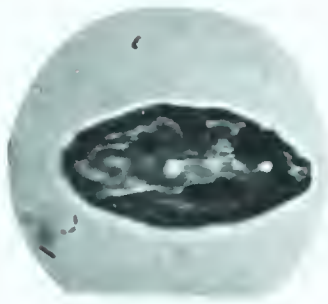

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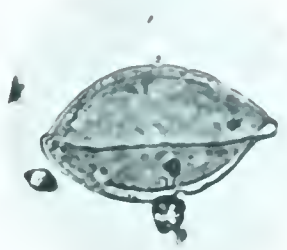

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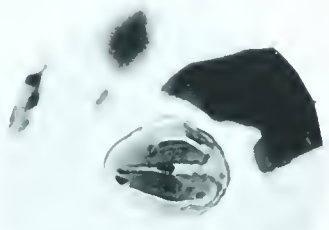

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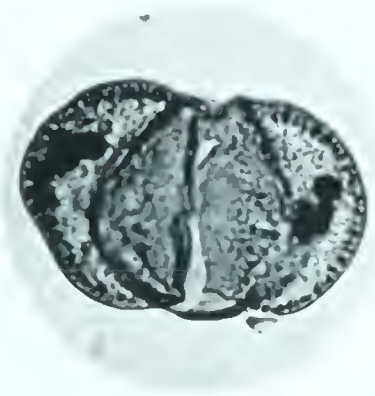

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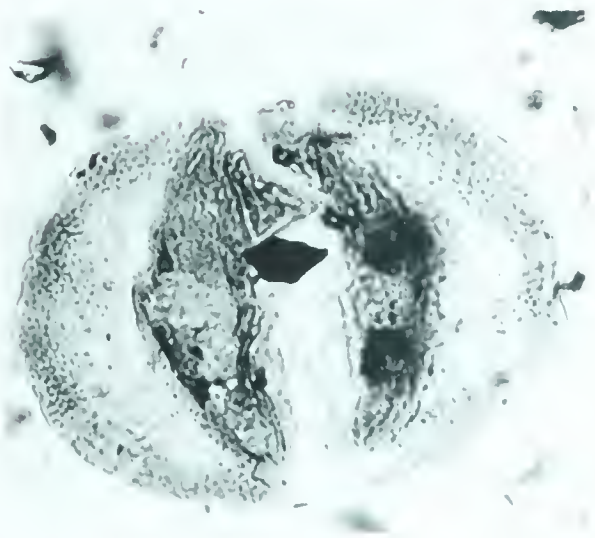

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PLATE 11

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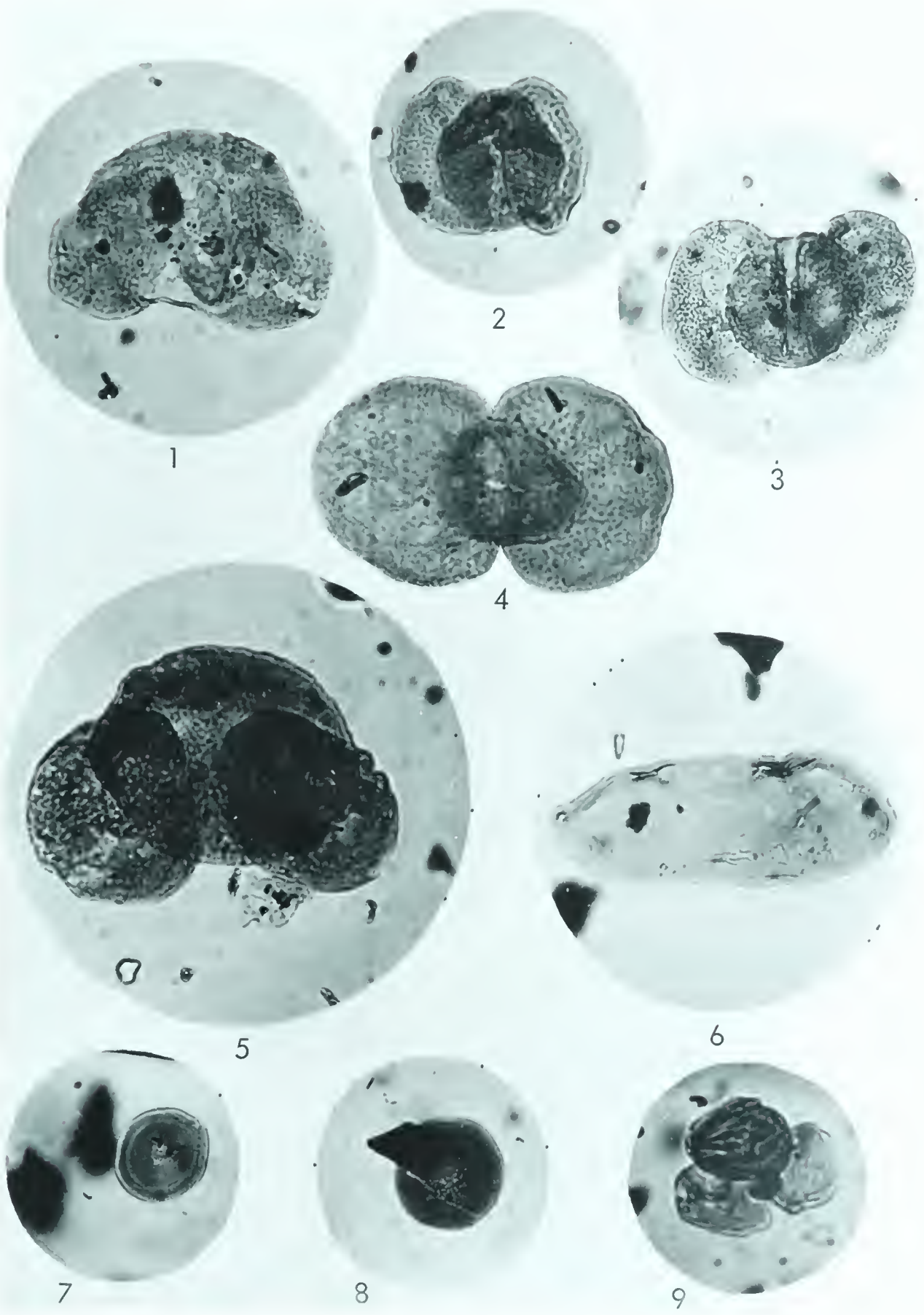
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PLATE 12

(All figures x 500 unless otherwise stated)

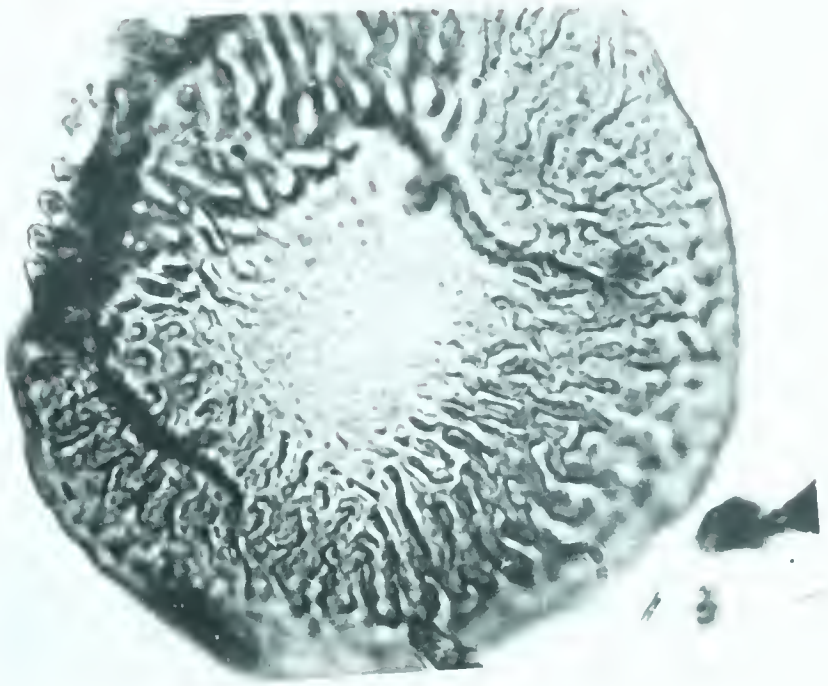
Figures 1,2,3. Tsugaepollenites radiostriatus n. sp.
1 - Holotype, distal view
2 - Holotype showing detail; x 1250
3 - semi-equatorial view, Paratype ..... (p. 86)

Figure 4. Vittatine cretacea Pocock; note small bladder ..... (p. 85)

Figure 5. Equisetosporites cf. E. ovatus (Pierce) Singh ..... (p. 86)

Figures 6,7. Polyad grains
6 - x 180
7 - note aperture

1



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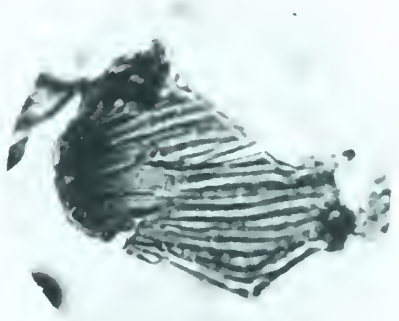

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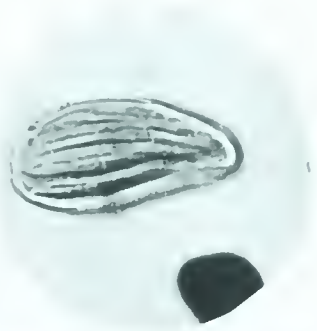

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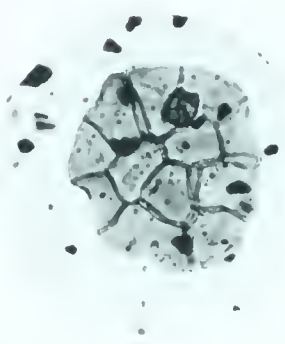

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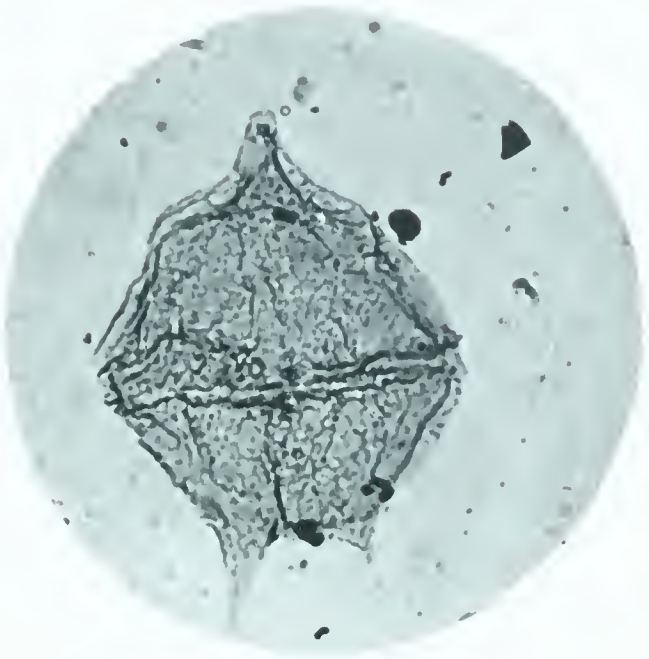
PLATE 13

(All figures x 500)



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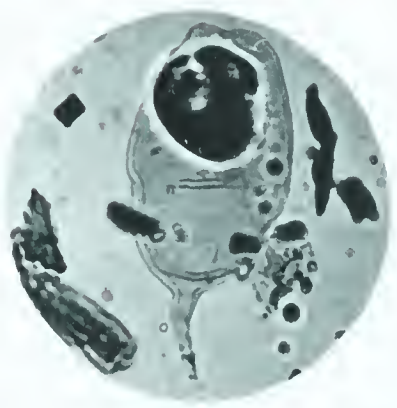

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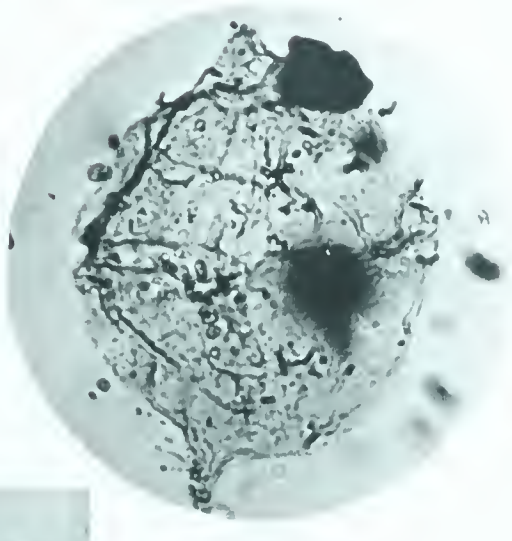

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PLATE 14

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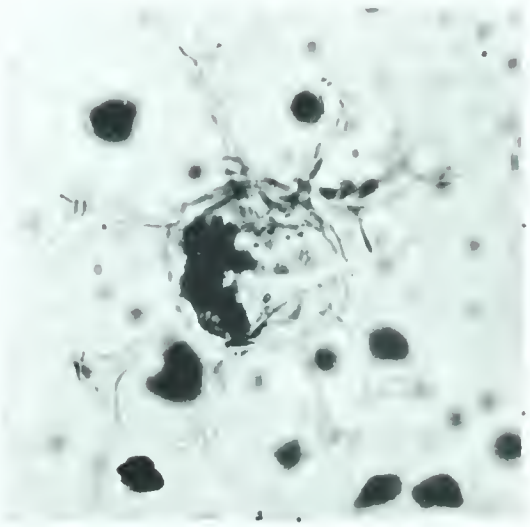

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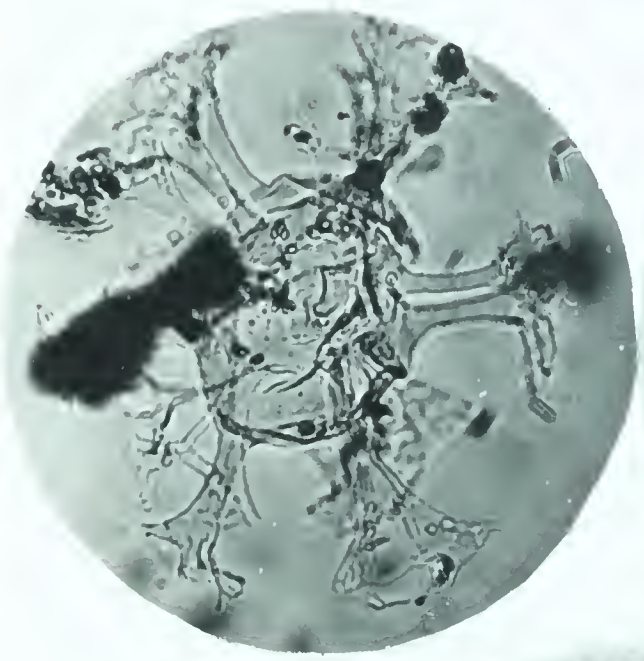

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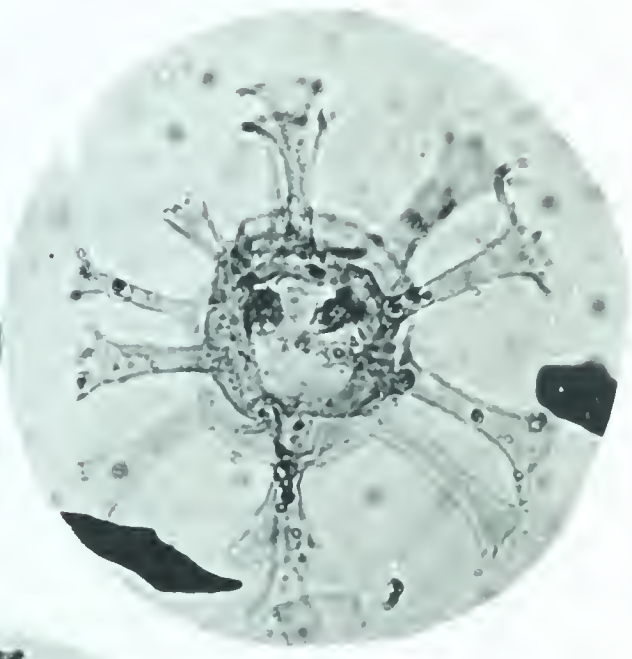

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TABLE A

DISTRIBUTION OF MICROFLORA
IN
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